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ANIMAL-POULTRY AND PRODUCTS RESEARCH
OTHER THAN HUSBANDRY, DISEASES, AND PARASITES

A summary of current program and preliminary report of progress of the United States Department of Agriculture and related work of the State Agricultural Experiment Stations.

This progress report is primarily a research tool for use of scientists and administrators in program coordination, development, and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of research progress include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members, and others having a special interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of U.S.D.A. and cooperative research issued during the past year. Current agricultural research findings are also published in the monthly U.S.D.A. publications, Agricultural Research and The Farm Index.

UNITED STATES DEPARTMENT OF AGRICULTURE
Washington, D. C. 20250

December 1, 1966

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RESEARCH ADVISORY COMMITTEES

The following Research Advisory Committees were established pursuant to Title III of the Research and Marketing Act of 1946:

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|-----------------------------------|-----------------------------------|
| 1. Farm Resources & Facilities | 8. Cotton |
| 2. Utilization | 9. Grain & Forage Crops |
| 3. Human Nutrition & Consumer Use | 10. Horticultural Crops |
| 4. Marketing | 11. Oilseed, Peanut & Sugar Crops |
| 5. Agricultural Economics | 12. Plant Science & Entomology |
| 6. Forestry | 13. Tobacco |
| 7. Animal and Animal Products | |

The source materials used by the advisory committees include organizational unit progress reports and subject matter progress reports. The latter contain information which was first reported in the organizational reports and has been assembled for use by commodity committees. The number prefixes shown below refer to advisory committees listed above.

ORGANIZATIONAL UNIT PROGRESS REPORTS

Agricultural Research Service (ARS)

- 1 - Agricultural Engineering
- 1 - Soil & Water Conservation
- 2 - Utilization -- Eastern
- 2 - Utilization -- Northern
- 2 - Utilization -- Southern
- 2 - Utilization -- Western
- 3 - Human Nutrition
- 3 - Consumer & Food Economics
- 4 - Market Quality
- 4 - Transportation & Facilities
- 7 - Animal Husbandry
- 7 - Animal Disease & Parasite
- 12 - Crops
- 12 - Entomology

Economic Research Service (ERS)

- 1, 5 - Economic Development
- 4, 5 - Marketing Economics
- 5 - Farm Production Economics
- 5 - Economic & Statistical Analysis
- 5 - Foreign Development & Trade
- 5 - Foreign Regional Analysis
- 5 - Natural Resource Economics
- 6 - Forest Service - Research (FS)
- 4, 5 - Farmer Cooperative Service (FCS)
- 4, 5 - Statistical Reporting Service (SRS)

SUBJECT MATTER PROGRESS REPORTS

- 6 - Forestry (other than Forest Service)
- 7 - Animal-Poultry & Products Research other than Husbandry, Disease and Parasite
- 8 - Cotton & Cottonseed
- 9 - Grain & Forage Crops
- 10 - Horticultural Crops
- 11 - Oilseed & Peanut
- 11 - Sugar
- 13 - Tobacco

A copy of any of the reports may be requested from Max Hinds, Executive Secretary, Animal and Animal Products Research Advisory Committee, Research Program Development & Evaluation Staff, U. S. Department of Agriculture, Washington, D. C. 20250

*taken from other
animal products
research -
per phone 4/24/67*

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This volume contains the results of animal-poultry and products research not included in the progress reports pertaining to "animal husbandry" and "animal diseases and parasites." This is one of eight subject matter progress reports listed on the opposite page. The information contained in this volume was assembled from the organizational unit progress reports. The subject matter areas are listed below.

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INTRODUCTION

All farm research pertaining to livestock and poultry except engineering and entomology is reported in the "animal husbandry" and "animal disease and parasite" progress reports.

Nutrition, consumer use, and utilization research pertaining to animal-poultry and products is conducted in the Agricultural Research Service Divisions of Human Nutrition, Consumer and Food Economics, Eastern Utilization, and Western Utilization Research and Development. The work comprises investigations of composition and nutritive value; physiological availability of nutrients and their effects; new and improved methods of preparation, preservation, and care in homes, eating establishments and institutions; and with the processing phase and manufacture into products. Also, it is concerned with improved equipment and processes.

Marketing and economic research pertaining to animal-poultry and products is carried on within four services: Agricultural Research Service, Economic Research Service, Farmer Cooperative Service, and Statistical Reporting Service. The work comprises (1) physical and biological aspects of assembly, packaging, transporting, storing and distribution; (2) economic aspects of marketing costs, margins and efficiency, market potential, supply and demand, and situation and outlook; (3) cooperative marketing; and (4) consumer acceptance studies. The divisions in which the work is conducted are: Market Quality, ARS; Transportation and Facilities, ARS; Marketing Economics, ERS; Economic and Statistical Analysis, ERS; Marketing Division, FCS; and Standards and Research, SRS.

Interrelationships among Department, State and Private Research

A large part of the Department's research is cooperative with State Experiment Stations. Many Department employees are located at State Stations and use laboratory and office space close to or furnished by the Station. Cooperative work is jointly planned, frequently with the participation of representatives of the producers or industry affected. The nature of cooperation varies with each study. It is developed so as to fully utilize the personnel and other resources of the cooperators which frequently includes resources contributed by the interested producers or industry.

About one-third of industry's contribution to the research effort pertains to farm research. Industry does most of its own poultry breeding research but very little beef breeding research, except the work of large firms like the King Ranch which developed the Santa Gertrudis breed. The scope of operation required for a successful research program in breeding beef cattle because of the size of animal and length of life cycle which tie up a substantial amount of funds, is undoubtedly a factor contributing to the amount of public research. In the case of swine there is a real

opportunity for increased participation by industry. The task of evaluating breeds, the performance of breeds in crossing, and the comparison of crossing systems will take more animals than are available at publicly-supported experiment stations.

About equal to the farm research effort in the livestock industry, another one-third is in the utilization field. In contrast with the public research in basic work the industry program places strong emphasis on developmental activities and solving of immediate problems. The work of meatpackers is devoted to finding industrial utilization of byproducts, quality control devices, improved formulation of products, improved handling and plant arrangement. Independent laboratories and foundations take on short time problem-solving for clients in the meat industry. Pharmaceutical firms carry on research on extraction of biologically active substances from meat byproducts such as hormones from glands, and with the development of agents, such as antibiotics for use in meat processing.

The contributions of producers and industry to the work of the State Stations and the Department have been an important factor in the success of their research programs. Producers offer herds and facilities for testing products and practices used in production. Likewise, processors and retailers offer facilities and products for use by public research agencies. Many problems in the economics of marketing cannot be transferred to a laboratory, experimental plot, or other simulated situation. The results of economic research conducted cooperatively is of great value to industry, especially in cases where public research can provide comparison and analysis. Even large firms that have a research staff do not have access to the plants and records of competitors.

Examples of Recent Research Accomplishments by USDA and Cooperating Scientists

Environment for Livestock Buildings. Research in cooperation with State Experiment Stations has obtained much needed basic data on the heat and moisture given off by cattle, hogs, and poultry, and on the influence of building environment on production and feed consumption. The heat and moisture dissipation data are considered basic design data for ventilation systems of poultry, dairy, and swine buildings. They appear in design handbooks including the Guide and Data Book of the American Society of Heating, Refrigeration, Ventilating, and Air Conditioning Engineers, and are used by makers of ventilating equipment, prefabricated buildings and package buildings as well as by specialists advising farmers on their own construction. Building improvements resulting from the above research have contributed to the substantial rise in efficiency of livestock production that has occurred during the past decade.

Electrical-mechanical control of horn flies. Horn flies on dairy cattle were effectively controlled with an electrochemical device which avoids the risk of contamination of cattle, milk, and milking equipment. BLB fluorescent lamps are installed in box-like containers and insecticide impregnated gauze protected by hardware cloth placed in front of the lamps. When units are installed on both sides of entrances, horn flies are attracted to the lights, contact the treated gauze and die in a few minutes. When operated in total or semidarkness, these devices reduced large horn fly populations by 90 to 95% within 7 to 10 days and maintained effective control thereafter. Studies are underway to create a semidark environment at entrances to barns to render the units effective at all hours.

Shelf Life of Dry Whole Milk Extended. The development by Department engineers of a continuous vacuum foam-drying process for manufacturing dry whole milk has largely eliminated the fat rancidity problem previously encountered in the making and distribution of this product. In this novel process the product is made, handled and packaged without any contact with air. The process also features low heat exposure, which in the virtual absence of oxygen improves storage stability.

The air-free process has been carried out successfully under pilot plant conditions which simulate commercial operation. After a year under ordinary refrigeration the experimental dried whole milk still has good flavor. It is expected that these favorable test results will stimulate the interest of dry milk manufacturers in the commercialization of the continuous vacuum foam drying process.

Losses in Cheese Manufacturing Reduced. Formerly many of the bacterial cultures used in cheese making were easily contaminated by bacteriophage, a virus that attacks the bacteria, interferes with its growth and prevents formation of the required acidity. A new method developed by Department scientists now prevents bacteriophage growth and activity and is in commercial use. The method, which consists of a phosphate-heat treatment of the milk used for preparing the starter cultures, is used widely by industry, particularly by Cheddar cheese manufacturers and by cheese culture supply houses. At least one company prepared its cultures in the phosphated milk and two large firms sell phosphated dry milk for use in preparing cheese starter cultures. It is estimated that the savings from use of this method in 1964 amounted to almost 2 million dollars and in 1965 to more than 4 million dollars. These figures are based on the prevention of a 1% loss in Cheddar production caused by starter failures and on a one-half cent per pound average increase in the value of the cheese made with phage-free starter.

Biodegradable Liquid Detergents Made from Tallow. Department scientists seeking a good outlet for surplus inedible fats have developed biodegradable liquid detergents from tallow. These products have excellent properties in heavy duty liquid detergent formulations. One of the new detergents is an excellent lime soap dispersing agent and can be used in liquid soap-detergent combinations for hard water use. The desirable and unexpected ease of solution of tallow-based detergents and their combination with soap will favor their commercial development. When liquid detergents were introduced in 1935 they represented only 7% of total detergent sales. Within a decade liquid detergents proved their utility and popularity. At today's levels the annual production of 14 hundred million pounds accounts for 33% of total detergent sales.

WURLAN II, An Improved Finishing Treatment for Wool. A new textile-finishing process, WURLAN II, extends considerably the range of polymer finishes that can be applied to wool. The process involves technology similar to that employed in the original WURLAN process. In WURLAN I, monomers are used to form polymers on wool; in WURLAN II, preformed polymers are used. The new process produces desirably soft, durably shrink-resistant wool fabrics, and the polymers used are low-cost and commercially available. Since many types of resins can be used, WURLAN II is particularly useful for developing multipurpose effects, such as soil resistance combined with shrink resistance.

New Soil-Resistant Finishes for Wool. Treatment with fluoropolymers provides the most effective soil-resistant finish for textiles, but these polymers have been exceedingly expensive. Now an entirely new synthesis has been discovered which gives promise of providing superior soil-resistant finishes at less than half of the cost of previously available treatments. From hexafluoroacetone, several new families of polymers have been made, including polyfluoroacrylates and polyfluoroethers. When these polymers are dissolved in the proper solvents, they can be applied easily to fabrics or finished garments to provide water- and soil-resistance that lasts through repeated laundering, drycleaning and wear. Some of the new fluoropolymers also make wool shrink-resistant; thus the way is open to new multipurpose finishes. The fluoropolymers can be used in combination with the WURLAN I treatment, which is now being widely used commercially to make wool machine-washable.

Measurement of Cohesiveness in Poultry Meat. A method has been developed for the mechanical measurement of the cohesive force holding fibers together in poultry meat. It provides, for the first time, an objective measurement of a texture defect found in canned, freeze-dried, and irradiated meats and associated with an undesirable crumbly, cottony feel in the mouth. Adequate cohesiveness is recognized as essential for good texture in meats. The method employs standard tensile-testing equipment and an adhesive compound that

forms a bond between metal and poultry meat stronger than the cohesive force within the meat. Cohesiveness measured by this method correlates well with the degree of degradation of the connective-tissue protein, collagen. This method for measuring cohesiveness added to the shear force method of measuring tenderness provides two valuable tools for research to improve texture of processed poultry products.

As a step toward implementation of the recommendations for a National Program of Research for Agriculture made jointly by the Association of State Universities and Land Grant Colleges and the USDA, a section has been added to each of the Areas in this report. It comprises a list of the related publications of the State Agricultural Experiment Stations in addition to those heretofore reported covering the results of USDA and cooperative research. In future years, it is anticipated that information will be available to permit reporting of achievements resulting from State research in a format comparable to the present reporting of the USDA and cooperative research.

Screening Method for Determining Salmonella Negative Samples of Dried Egg. Salmonella bacteria in foods can cause serious food poisoning. Present methods of examination of dried whole egg for these pathogenic bacteria are time consuming and expensive. We have developed a screening which requires no expensive equipment and produces reactions which are readily observed. The method consists of determining hydrogen sulfide production and mannitol fermentation in conjunction with the lactose broth pre-enrichment for Salmonella. The test has proven highly accurate with pasteurized dried whole egg.

"Hot" Processed Pork Has Application to the Meat Industry. Recently completed laboratory research shows that processing pork carcasses immediately after slaughter is feasible and that no significant differences from conventional processing exist insofar as appearance, flavor, tenderness, juiciness, yield, and color stability are concerned. Bacterial studies show reduced microbial count indicating the new process results in a finished product of greater stability. Research was also completed on optimum time, temperatures, and air velocities for quick-chilling the hot processed pork products.

Meat Sanitation and Temperature Control Research. By changing the display conditions of packaged fresh red meat in display cabinets in accordance with research findings shelf life was extended and dollar loss from reworking packages was reduced over 80 percent. This is a potential savings of over 360 million dollars per year if the findings can successfully be adopted by U. S. supermarkets. The research done over the last few years has extended shelf life in retail stores to 7 days when properly handled.

Model Egg Plant Constructed. An egg plant of a marketing cooperative was designed as a model for the industry and has such features as facilities for washing, grading, breaking, pasteurizing, freezing, and further processing of eggs. The plant will more than double the volume of eggs being processed by the marketing cooperative and will reduce the costs per unit processed through the use of efficient work methods and the latest in materials-handling equipment.

Wool pools. A nationwide study was completed of 234 wool pools that marketed 16 million pounds of wool for 36,000 growers. Findings indicate that wool pools enable growers to market their wool more effectively and increase their net returns from wool by 3 to 4 cents a pound. A report was published suggesting methods for improving pool organizations, assembly, grading, selling, and management practices.

Cooperative marketing of nonfat dry milk. A study of the experiences and practices of cooperative dry milk manufacturers and the experiences of commercial users of the product shows that to improve marketing efficiency, more direct contact is needed between manufacturers and users, better training in the use of dry milk in specific products is needed for salesmen, and more coordination is desirable for effective sales and service activities.

Improved Medical Pads and Paint Rollers Recapture Markets for Shearlings. Shearlings--sheepskins tanned with the wool on--are now made commercially by tanning with glutaraldehyde in a process developed by Department scientists. The shearlings are used in hospitals as bed pads for the cure and prevention of bed sores. The shearlings made by the new process resist the detanning action of water and the deteriorating effect of alkaline chemicals so that the hospital pads have greatly improved launderability. Shearlings prepared by the new process are also used in paint rollers which resist the deteriorating action of water-based latex paints, so the rollers perform better, last longer and are easier to clean. The new process is effectively meeting the competitive inroads which man-made substitutes have been making in markets for conventionally tanned shearlings.

New Process Improves Water Resistance of Leather. Newer synthetic materials are replacing leather in shoe uppers at an increasing rate. These substitutes are promoted, in part, because of their resistance to weather and water. Easywettability has always been a serious drawback of leather shoes. To overcome this deficiency, water-repellent agents such as silicones and fluoro-chemicals, have found application to a limited extent. Eastern Division research has developed a process that makes these agents more efficient. The process involves the retannage of chrome leather with glutaraldehyde, followed by a novel procedure for lubrication with alkenyl succinic acids. One tanner has already commercialized the process and introduced a water-proof leather for use in boots and another sportswear articles. Prospects for wider commercial adoption of the process appear very favorable.

Examples of Recent Accomplishments of the State Agricultural Experiment Stations

Improved Process for Producing Dry Whole Milk. An improved process for producing dry whole milk has been developed by a dairy scientist at the Pennsylvania State University. The process will produce dry whole milk with significantly improved taste and odor qualities compared with products from conventional processing. Tasty dry whole milk should increase the sale and use of milk, particularly in areas of the world where fresh milk is not available. The process has been evaluated in both industrial and government laboratories and has been found an effective means of improving dry whole milk. A commercial product based on the process is undergoing test marketing. The new process takes milk fat, separated from whole milk, and treats it with steam under a relatively high vacuum. The fat can then be re-emulsified into skim milk. At this point the product can be evaporated into dry whole milk or can be used in dry ice cream mixes or dry cream powders.

Faster Cheeses by Direct Acid Method. University of Wisconsin dairy scientists have found ways to make Cheddar cheese, cottage cheese, and Italian cheese, in a fraction of the traditional time required. Now they have done the same thing to the process of making blue cheese. Since hydrochloric acid is used to coagulate the milk, the manufacturing time is cut in half.

Lactic bacteria have not been completely replaced, since they still must be used as a starter. In the direct acid method, HCl acidifies the milk to pH 5.6, then rennet is added to coagulate the curd. After the curd is worked, lactic acid bacteria continue to increase the acidity so the pH reaches 4.8 one day after manufacture. The lactic bacteria are used to control fermentation during the curing process.

Tests indicate that blue cheese made by the direct acid method has the same texture, color, and quality, as natural blue cheese and a satisfactory flavor.

Amount of Muscle Contraction Influences Beef Tenderness. Wisconsin Station scientists, while investigating factors which make a piece of meat tender or tough, found that contraction (how much a muscle shortens after slaughter) affects tenderness. Under special experimental conditions, muscle portions were removed from the carcass and put under tension while cooling. These muscles were tender. When portions of the same muscle were free to contract as they cooled, they were tough. The extent of contraction induced by treatment was reflected by the sarcomere length. Further, a positive association was found to exist between organoleptic tenderness and sarcomere length. Shear force measurements on the cooked meat also indicated that the muscle which was allowed to shorten was much more tender than that which was permitted to contract. Although the amount of muscle contraction must now be considered one of the important factors affecting tenderness, Wisconsin scientists feel that tenderness can probably not be best explained by a single factor such as amount or kind of connective tissue, amount of fat or marbling,

or sarcomere length. Sarcomere length, as a measure of contraction state, is probably only a gross indication of the molecular changes occurring in the actin and myosin of muscle. Thus the molecular changes associated with contraction appear to be a fruitful area for further research.

A New Preserving Technique for Pork Sausage. The New Jersey Agricultural Experiment Station has discovered that a specially coated salt will extend the freshness of sausage beyond its previous limits because the coat protects against the pro-oxidant effect of salt. When salted pork sausage is frozen it becomes rancid in about three weeks. When treated with a salt coated with hydrogenated fat and frozen, the sausage is no different than before in appearance, has a genuine sausage taste after cooking and remains free of rancidity for much longer periods of time. For sausage makers, this discovery means that they will be able to make larger batches of sausage, particularly important during seasonal peak of pork production and ship them greater distances.

Fate of bacteria in chicken meat during freeze-dehydration, rehydration and storage. Scientists at the Georgia station have studied the fate of bacteria in chicken meat during freeze-dehydration, rehydration and storage. Survival of the natural flora was determined after the meat was freeze-dehydrated and rehydrated at room temperature for thirty minutes, at 50, 85 and 100° C. for ten minutes. Total counts of bacteria in the rehydrated samples of meat were determined during storage of the meat at 4, 22, and 37° C. until spoilage odor was detectable. Meat samples were inoculated with Staphylococcus aureus, then dried, rehydrated and stored at the same room temperature. Numbers of surviving organisms in the inoculated samples were determined with use of both selective and non-selective media. The study indicates that freeze-dehydrated meat should be produced with adequate microbiological control and that such meat should be rehydrated in very hot water since survival of vegetative cells of potential food poisoning or food infection organisms is a distinct possibility in freeze-dehydrated meat.

Detection of Salmonella in eggs and egg products with fluorescent antibody. Salmonellosis is one of the important food-borne infections in the world today. Iowa station scientists studied the usefulness of the fluorescent antibody technique for rapid Salmonella detection in dried egg products. Organisms of the genus Salmonella are detected in eggs and egg products within 24 hours in the presence of Pseudomonadaceae and other Enterobacteriaceae by combining selective cultural methods with fluorescent antibody techniques. These techniques are specific for Salmonella when H antibodies are used. Absorption techniques are necessary before the O antibodies give specific reactions for Salmonella. No cross-reactions appear when H antiserum is used. Absorption and interference techniques indicate the list is specific for Salmonella. Work was supported in part by grants from the U.S. Public Health Service and the USDA.

Definition of Carcass Merit in Lamb. As a result of research in W-61, Development of Selection Criteria for the Genetic Improvement of Carcass Merit in Sheep, a definition of carcass merit in lamb was developed which is in effect, a carcass standard for high merit. The standard includes fat thickness over the loin, loin eye area, percent retail cuts, dressing percent, and uniform distribution of fat cover with discrimination against excessive cover over certain cuts.

Improvement of Keeping Quality of Butteroil. Researchers at Rutgers University have improved the keeping quality of butteroil by a very slight hydrogenation. The hydrogenation takes place under low pressure, low catalyst concentration and at a temperature of 140°C. Organoleptic evaluation shows the hydrogenated samples to have much improved keeping quality. The improvement in keeping quality is obtained through only a little loss of unsaturation. The unsaturation may be restored conveniently by the process of winterization. Hydrogenation and winterization are processes presently used on edible fats.

As a step toward implementation of the recommendations for a National Program of Research for Agriculture made jointly by the Association of State Universities and Land Grant Colleges and the USDA, a section has been added to each of the Areas in this report. It comprises a list of the related publications of the State Agricultural Experiment Stations in addition to those heretofore reported covering the results of USDA and cooperative research. In future years, it is anticipated that information will be available to permit reporting of achievements resulting from State research in a format comparable to the present reporting of the USDA and cooperative research.

I. FARM RESEARCH

LIVESTOCK INSECTS AND OTHER ARTHROPODS
Entomology Research Division, ARS

Problem. Insects and other related arthropods attack all classes of livestock and poultry causing estimated annual losses of \$877,850,000. Losses are attributed to direct attack of arthropods causing losses in weight gains and milk and egg production and losses in the value of livestock products such as meat, hides, and wool. Additional losses result from livestock and poultry diseases spread by arthropod vectors. A large variety of insects and other arthropods affect livestock including mosquitoes and biting gnats, house flies, horse flies and deer flies, ticks and keds, the face fly, the stable fly, the horn fly, cattle grubs and other bots, lice, mites, and fleeceworms. Practical but not adequate control methods for many of these livestock pests have been developed, but satisfactory methods of protecting livestock and poultry from mosquitoes, biting gnats, horse flies, deer flies, and stable flies remain an unsolved problem. Development by insects of resistance to control chemicals is a continuing potential threat to current effective methods of control employing chemicals. The occurrence of insecticide residues in meat and animal products restricts the usefulness of some chemical control methods. Continued basic and applied research is needed to develop new, safer, more effective chemical control agents and methods of using them as well as other methods, such as management practices, sterilization, attractants, and biological control into highly effective integrated means of control or eradication. Research is also needed to study the role of insects in the spread of diseases of livestock and poultry.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing, long-term program involving basic and applied research on the biology and control of insects and related arthropods which affect the health and productivity of all classes of livestock. The total Federal scientific effort devoted to research on livestock insects is 37.8 scientific man-years and includes studies on: (1) beef, horse and swine insects; (2) dairy cattle insects; (3) sheep and goat insects, and (4) poultry insects. Research is conducted on: (A) basic biology, physiology, and nutrition; (B) conventional insecticide control methods; (C) insect parasites, predators, and pathogens; (D) insect sterility and other new approaches to control; (E) attractants and repellents; (F) insect vectors of diseases; and (G) program leadership. The following tabulation indicates the distribution of scientific man-years between commodity groups (1-4) and types of research (A-G).

	A	B	C	D	E	F	G	Totals
1	6.2	2.2	1.8	3.3	2.4	0.4	0.6	16.9
2	4.6	2.2	1.0	3.3	1.7	0.4	1.0	14.2
3	1.2	0.8	0.3	1.0	0.3	1.0	0.2	4.8
4	---	1.2	---	0.5	---	---	0.2	1.9
Totals	12.0	6.4	3.1	8.1	4.4	1.8	2.0	37.8

Federal support in research grants, contracts, and extended cooperative agreements provides for 11.8 scientific man-years per 3 years. Commodity distribution is 4.8 to beef insects; 3.6, to dairy insects; 2.2, to poultry insects and 1.1, to sheep and goat insects. Research area distribution is 5.1 to basic biology, physiology, and nutrition; 1.6, to conventional insecticide control methods; 3.0, to insect parasites, predators, and pathogens; 0.8, to insect sterility and other new approaches to control; and 1.3 to attractants and repellents. Grants, contracts, and extended cooperative agreements are located at the following institutions: University of California at Berkeley, University of California at Davis, University of Georgia, Athens, University of Kentucky, Lexington, McNeese State College, Lake Charles, La., University of Southwestern Louisiana, Lafayette, Louisiana State University and A&M College, Baton Rouge, Mississippi Agricultural Experiment Station, State College, New Mexico State University, Las Cruces, University of Utah, Salt Lake City, Virginia Polytechnic Institute, Blacksburg, University of Wyoming, Mississippi State University, and Instituto Nacional de Investigaciones Agricolas, Secretaria de Agricultura y Ganaderia Estados Unidos Mexicanos.

Additional research is conducted under grants supported by P. L. 480 funds. A13-ENT-3, entitled, "Investigations on the biology of dung beetles in Korea and their role in the prevention of fly breeding in dung", is under study at the Department of Agricultural Biology, College of Agriculture, Seoul National University, Suwon, Korea; A10-ENT-12, entitled "Laboratory study of tick repellents and acaricides", at the Veterinary Institute, Beit Dagan, Israel, and S9-ENT-6 entitled, "Investigations on natural enemies of ants" at Ministerio de Ganaderia y Agricultura, Montevideo, Uruguay.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 36.5 professional man-years is devoted to this area of research.

PROGRESS USDA AND COOPERATIVE PROGRAM

A. Basic Biology, Physiology, and Nutrition

1. Mosquitoes (All livestock). At Gainesville, Fla., bacterial infusions of hay and fresh grass have been found to stimulate growth in Aedes aegypti, Anopheles quadrimaculatus, Aedes triseriatus, Aedes taeniorhynchus, and Culex quinquefasciatus. In preliminary tests these infusions have also been found to stimulate oviposition and egg hatch and induce autogeny. There is also some indication that they contain substances which attract mosquitoes. Research is now under way to determine whether bacteria or chemical substances are responsible for these stimulations and responses.

Tests conducted to determine whether females of Culex p. quinquefasciatus mated more than once showed that females did not re-mate and one mating was sufficient to satisfy mating requirements of females.

At Lake Charles, La., studies on the biology of mosquitoes were continued. The blood feeding and oviposition behavior of Aedes canadensis was studied. One blood meal was required to produce one batch of eggs. In the laboratory, females would not take more than 3 blood meals or lay more than 3 egg batches. None of the eggs hatched showing that this species is univoltine in this area. In an attempt to compare the degree of hatching of eggs of some floodwater species of Aedes with the number of times the eggs were flooded with water, open and screened enclosures were build over breeding sites on marsh areas. In one of four sets of open and screened enclosures, it appeared that all of the hatchable eggs had been depleted after numerous floodings over one year. The remaining screened enclosures, continued to produce sizeable but smaller broods of larvae than the open enclosures.

At Corvallis, Oreg., studies were continued on the basic biology of mosquitoes. Exposure of Culex quinquefasciatus females to low levels of light during the night influenced their behavior and response to attractants the following day. Surveys on mosquito abundance indicated that C. tarsalis and C. peus were less abundant in the Willamette Valley in 1965 than in previous years. During the fall of the past 3 years larvae of Aedes increpitus have been collected rather widely in the flood plain of the Willamette River indicating that this increpitus strain is well-adapted to the region.

Research has been continued under two contracts at the University of Southwestern Louisiana and McNeese State College. Light trap collections have shown the relative abundance and dispersion of different species of mosquitoes. Correlations of the occurrence of floodings and high tides were made and showed that the numbers of Aedes sollicitans trapped during the second quarter of 1965 were higher than the numbers of Culex salinarius and this trend was reversed during the 3rd and 4th quarter. Data on temperature, rainfall, and the direction and velocity of wind are being gathered to correlate with abundance and dispersal of various species. The seasonal activity of several important species of mosquitoes was

determined in two areas in Louisiana. Aedes sollicitans and C. salinarius were present and active throughout the year except for short periods of no significant rain or high tides. Culiseta inornata was caught only in the cooler months; while Mansonia perturbans and Psorophora confinnis were active only in the warm months. Anopheles quadrimaculatus was absent from one area and relatively scarce in the other. Culex quinquefasciatus was found only in one spot near a residential area where a few premises were not well cared for.

2. House Flies (All livestock). At Corvallis, Oreg., research was continued on the basic biology of the little house fly. Field collected, p³² labeled little house flies were released for migration studies. Flies dispersed throughout a poultry farm and fur farm within 24 hours. Studies were conducted on the mating behavior of the little house fly. Males were shown to be capable of successfully fertilizing at least 7 females each. Preliminary tests indicate females may mate more than one time. Wild-collected females deposited eggs that were 72 to 82% viable. Excess numbers of males caged with females did not increase female mortality or decrease fecundity or fertility.

3. Horse Flies and Deer Flies (All livestock except poultry). At Stoneville, Miss., eggs were obtained from 16 species of Tabanidae in a specially developed oviposition chamber. Tabanus proximus, T. vittiger schwardti and T. atratus oviposited more readily in confinement than other species. The eggs of several species had never before been observed. The egg masses of each of the species is distinctive, thus providing a means of identification of the species in the absence of adults. These findings together with the development of techniques for rearing the larvae in the laboratory represent significant advancements in our knowledge of the Tabanidae. The incubation for most of the species has been determined and the larvae of some species have been reared to maturity. Several species are fairly easily reared and one, T. vittiger schwardti has been successfully colonized. The larval period of this species ranged from 104 to 147 days in spring rearings to only 50 to 63 days in the fall. The pupal period ranged from 4 to 11 days. Differences in developmental rates presumably are related to temperature. In some groups of larvae 39% have survived to pupate and 72% of these have produced adults. The life cycle of other species varied greatly. The larval period of T. abdominalis ranged from 212 to 526 days; T. proximus from 522 to 547 days; T. lineola from 107 to 195 days. Pupal periods from these three species were 14-15, 12 and 4-9 days, respectively.

At Stoneville, Mississippi, a 12-day study (July 12-23) was conducted to determine the number and species of tabanids attracted to bait animals and the percentage of these that actually fed. Landing rates were highest from 8 to 10 AM and 2 to 4 PM, whereas, the percentage feeding were highest from 10 AM to 2 PM when populations were low to moderate. There was some correlation between percent feeding and solar

radiation, but an inverse correlation between solar radiation and landing rates. The effects of temperature and humidity were not clearly evident from data obtained and further studies will be necessary to determine their influence on adult Tabanid behavior. Feeding rates for the various species of tabanids ranged from 3.2% for T. lineola and 6.5% for T. vittiger schwardti (the most numerous species) to 100% for T. proximus, with the overall average being 30%.

Special studies were conducted in Mississippi, to elucidate the feeding habits of several important species of horse flies. It was found that several species were capable of taking 2 blood meals and T. atratus took 3. These species oviposited after both the 1st and 2nd blood meals.

At Kerrville, Texas, extremely large populations of horse fly larvae were found in fecal matter in a dairy barn drainage area. About 80% of the larvae were T. atratus and 20% T. vittiger schwardti. The larvae of these species are predaceous. Apparently they were feeding mainly on the abundant supply of other dipterous larvae.

Research has been conducted under grant support at the University of Wyoming on the biology of tabanids. Specimens were collected throughout the state for identification of species, densities of populations, and time of activity. Females of Hybomitra frontalis were maintained in the laboratory for 19 days on a diet of sugar, dry Dimalt and water. Observations indicated tabanids in Wyoming tended to land on the head, shoulders, and sides of cattle. They preferred darker areas of cattle. Motion influenced attraction of the tabanids.

4. Screw-worm (All livestock except poultry). A Mexican strain of screw-worm flies has been derived from 62 individual egg masses collected in Veracruz, Mexico and 9 combined collections of egg masses from Sinaloa, Mexico. All cross matings were controlled to insure the maximum genetic variability in the final gene pool. This strain is being tested for possible use in Mexico by the Southwestern Screw-worm Eradication Program.

After 7 generations of laboratory colonization, Mexican strain screw-worms still have a longer developmental cycle on artificial medium than those of the Florida strain. Larvae of the latter strain leave the medium after 70 to 77.5 hr as compared to about 85 hr for larvae of the Mexican strain.

Mating frequency among male screw-worm flies appears to be a function of the degree of adaptation to laboratory conditions. Mean matings per male in one hour increased from 1.5 to 7.5 after a newly introduced strain of screw-worms had been reared through 18 generations in the laboratory. Sexual aggressiveness tests on males from 6 strains of flies reared in the laboratory for 5, 15, 26, 41, 69, and 100

generations also indicated that harassment of females by males increased with time in culture. Apparently both size and strain affect mating activity. Large males flies are more successful than small males of the same strain in mating with large female flies. This difference is greater when females from a recently colonized strain are used.

Studies were continued on the rate of development of screw-worm larvae in artificial media and in wounds on animals. Larvae in horsemeat medium reached the 3rd instar in 36 to 48 hours after hatching while a period of 70 to 78 hours was required by larvae in fresh wounds on sheep. More than 90% of the larvae had left the horsemeat medium after 96 hours. Larvae in fresh wounds on sheep required 168 hours to complete feeding. Larvae placed in previously infested wounds on sheep developed as rapidly as those on artificial medium, but remained on the animals 24 hours longer in the 3rd instar.

A field test was run for 6 months near Poza Rica, Veracruz, Mexico to compare the efficacies of 2 diets used for rearing the sterilized screw-worm flies being released in the Southwest Screwworm Eradication Program. Wounded test animals, arrayed systematically over 2 separate but similar test areas, were used to attract oviposition by native female screw-worms. One test area was treated with sterile flies raised on horsemeat, the other area with flies raised on the liquid diet. Both areas received 420 flies per square mile per week, dropped by airplane along fixed flight lanes 12 miles apart. Ratios of sterile to fertile egg masses laid on the wounded test animals were used to measure relative efficacy of the diets. Sterilized flies raised on horsemeat induced slightly more egg mass sterility than did those raised on liquid diet, but the differences were not striking, and the ratios of sterile to fertile egg masses ran lower than expected throughout the test. Sterile egg masses appeared more often directly under the flight lanes than either 3 or 6 miles away, but again the differences were not great.

A 4-month comparison of burros with sheep for use as wounded test animals in attracting oviposition by native female screw-worm flies in Mexico demonstrated that the cost of preventing the burros from ridding themselves of screw-worm eggs or larvae was too great to make them a practical substitute for sheep.

An analysis of the population dynamics of screw-worms in Mexico was accomplished by employing a method for making contour maps of isopleths of reported screw-worm infestations. Three major areas of infestation exist year-around with apparent independence of each other, one on the Caribbean coast below 20° N Lat., a second on the Pacific coast below 19° N Lat. and the third on the Pacific coast between 19° and 26° N Lat. All other parts of Mexico experience marked annual declines (or losses) of screw-worm populations due to severe cold and/or drouth and seem to derive new populations from the 3 major areas. Some

overwintering does occur outside the major year-around centers of activity. The analysis provides quantitative estimates of case abundance, by seasons, and suggests ways to relate case abundance to numbers of sterile flies needed for eradication and/or control.

Studies were continued on the reproductive behavior of the screw-worm fly. Few matings with virgin 5-day-old flies were recorded for each sex at 1 day of age, but the number of successful matings rose rapidly to 3 days of age. Thereafter, male sexual aggressiveness declined and female receptivity increased very slightly to 14 days of age. Almost 75% of copulating 1-week-old males transferred sperm within 15 seconds of commencement of mating. A maximum of about 90% of males transferred sperm when copulations approached completion.

Newly emerged females exposed to sexually mature males for 1-10 days began laying eggs of normal viability on the 3rd day and oviposition increased to the 5th day. When newly emerged males were exposed to sexually mature females for 1-10 days, oviposition and hatchability were low after 1 day of exposure, but oviposition was maximal for the 2nd day and hatchability was maximal for the 3rd day.

Two groups of 5-day-old mated females were subjected to $0.5+1.5^{\circ}\text{C}$ for one hour allowed to recover at 27°C , and 24 hours later the females of 1 treated and an untreated group were each combined with untreated males in a 1:2 ratio. The cold treatment had no adverse effect on survival or egg production. A reduction in hatchability of eggs from mature mated females treated with cold was attributed to inactivation of some of the sperm stored in the females. Elevated hatchability of eggs from mature mated females treated with cold and offered an opportunity to remate suggested that some partially deseminated females mated again.

Females isolated individually for the first 5 days of adult life and then mated to 5-day-old males were less fecund and fertile than females maintained together in groups of 50 prior to mating.

The length of unselected puparia were measured with a metric micrometer caliper and later associated with the sex of the contained fly upon its emergence. Male puparia were longer than female puparia within a single rearing group, but there were differences in length between one rearing group and another.

5. Stable Fly (Cattle and horses). At Kerrville, Texas, studies showed that male and female stable flies normally remain in copulation from 3 to 7 minutes. From 60 to 90 percent of the females were inseminated in the first mating. Results indicated that female flies probably do no remate if sperm is transferred in the first mating.

In Texas, studies were undertaken to study the responses of stable

flies to photoperiods. Pupae within two days of emergence of adults were used in all tests. Results showed that females produced an average of 77 eggs under continuous light, 56 eggs under continuous darkness and only 16 eggs under 12 hours light and 12 hours darkness.

At Corvallis, Oregon, studies were undertaken on the feeding habits and nutrition of stable flies. Studies have shown that blood feeding is required by females for the production of viable eggs; however, males can successfully fertilize females without feeding on blood. Both sexes survived well on carbohydrate diets and/or sources of protein other than blood but no viable eggs were produced. Attempts are being made to select strains with differing nutrient requirements for egg production.

6. Face Fly (Cattle and horses). At Corvallis, Oregon, surveys were made for the presence of face flies, Musca autumnalis. This fly has not been reported in Oregon, but has recently been discovered in two neighboring States, Idaho and Washington. Two surveys in Central, Eastern, and Northeastern Oregon failed to show the presence of face flies.

7. Cattle Grubs. At Kerrville, Texas, studies were continued to obtain more information on the biochemical and physiological requirements of second and third instar larvae of cattle grubs and to develop methods for rearing larvae under laboratory conditions. A satisfactory synthetic media was developed but bacterial contamination made it impossible to keep larvae alive over 2 weeks. This problem was partially overcome by sterilizing the larvae in a saline - antibiotic wash and transferring them to sterile containers containing culture media. Subsequently, an automatic system was developed for feeding the larvae in cells in sponges. This system avoided the use of excess media and larval survival increased markedly.

In Texas, several improved synthetic media were developed for studies on rearing cattle grubs under laboratory conditions. The rate of increase in weight of cattle grub larvae in these media was twice that in those previously tried. Past problems of contamination were largely overcome by sterilizing cattle gullets prior to removal of grub larvae and by keeping the larvae in sterile media. In subsequent tests ultraviolet light further improved bacterial control. In this environment some first instar larvae survived for over 90 days but none molted to the second instar. Recent studies have shown that first stage grub larvae survive longer when maintained in small cheese cloth bags. Survival and development has also been enhanced by the use of an improved automatic feeding device.

In preliminary studies improved emergence of flies from pupae was obtained by varying holding temperatures from 5° to 25° C rather than

holding at a constant temperature.

In Texas, in 1965, H. lineatum larvae first appeared in the backs of cattle early in October, and reached a peak December 10 - January 7, with 80% being in the third stage. By February 18, practically all were of this stage, whereas the first few larvae of H. bovis were just appearing.

In Oregon, studies were conducted to observe the behavior, pupation site preference and duration of the prepupal stage of H. bovis cattle grub larvae newly emerged from the backs of cattle. The larvae tended to burrow under anything in their paths, such as plants, roots, sticks and cattle droppings, but others preferred to pupate at the bases of clumps of grass or other vegetation. The larvae appeared to be negatively phototropic regardless of weather conditions. Migration times ranged from 6.0 to 77.0 hours and distance traveled ranged from 6.5 to 110 inches. Pupation sites were covered with cages and observed regularly for adult emergence. The pupation period ranged from 30 to 39 days for larvae pupating from May 5-12 and from 40 to 49 days for those pupating April 20 - May 2. Nearly 80% of the pupae produced adults. Mean dates of adult emergence were June 11-16. Average adult longevity ranged from 3.9 to 5.2 days. In the laboratory the duration of the pupal stage averaged only 20 days and the adults lived about a day longer than field emerged adults.

8. Horn Fly (Cattle). In Texas, techniques were perfected for mass rearing of horn flies under laboratory conditions. The flies were confined in 8.5 inch square plastic screen cages under continuous light. Absorbent cotton pads soaked with beef blood were provided for food. The two sexes copulate readily. Females drop their eggs at random and they fall through the bottom screen cages onto trays. The eggs are then counted and placed in trays of manure. Under these conditions the average time from egg to adult is 12 days and from egg to egg, 17 days. A colony of 50-60,000 flies is being maintained for experimental uses.

An artificial medium was developed in order to produce a uniform colony which was not attainable because of the wide variation in cow manure, the normal rearing medium. The media consists of 22 g of sugar cane pulp, 4 g of whole wheat flour, 500 mg of sodium bicarbonate, 300 mg of dehydrated ox gall and 110 ml of water. This medium was the best of a large number tried and produced uniform flies for resistance tests and other experimental uses.

Studies were continued in Texas, on the selection of horn flies for resistance to ronnel. The colony showed about 100-fold resistance after 43 generations of selection. An even higher degree of resistance was evident after 48 generations, with topical applications of 1.0 ug/fly causing only 38% mortality. Efforts to induce resistance to

toxaphene were unsuccessful.

9. Ticks (Cattle). At Kerrville, Texas, a 5-year study on the seasonal abundance of ticks on cattle was completed. The lone star tick (Amblyomma americanum (L.)), the most abundant species, was found on cattle throughout the year; some in February, rapidly increasing in numbers until activity peaked in March-June, rapidly decreasing in numbers through August, with only a few ticks present from September to January. Peak populations of adult lone star ticks, as determined by dragging pastures, coincided with peaks of infestations on cattle. The winter tick (Dermacentor albipictus (Pochard)), another abundant species, appeared first on cattle in October; activity peaked in November - January and decreased rapidly in February-March until almost no ticks were found in April-September. The black-legged tick (Ixodes scapularis Say), a less common species, appeared on cattle in October; activity peaked in November-December, few ticks were found in April-September. Ears of animals were examined and the abundance of nymphal ear ticks (Otobius megnini (Duges)) were recorded. This species had an inconsistent peak in late summer, -early fall, but the seasonal relationship was not well defined.

10. Mites (Poultry). Under grant support research has been undertaken on the biology of the mite, Neoschongastia americana, which is a pest of turkeys. Techniques have been developed to culture this mite and study its biology under field conditions. Preliminary research has demonstrated that most infestations occur between the legs and the body. Feeding injury caused by one mite will attract many mites. Only the larval stage is parasitic.

B. Insecticidal and Sanitation Control

1. Mosquitoes (All livestock). At Gainesville, Florida, the search for new and safer insecticides for mosquito control was continued. The most effective material screened as a larvicide was Dursban. Two other materials were slightly less effective. Against adult mosquitoes in laboratory wind-tunnel tests, 7 compounds were more effective than and another 10 equal to the standard, malathion.

In field tests against Aedes, Psorophora, and Culex larvae in small pot-holes, Abate and Dursban gave excellent control at dosages of 0.005 to 0.1 lb/acre. In field tests low-volume aerial applications of naled, naled-malathion mixtures, fenthion, and fenthion-Bay 39007 mixtures were evaluated for the control of adult salt-marsh mosquitoes. All treatments were highly effective in reducing mosquito populations. Some mixtures gave control over longer periods and studies are being undertaken on residual effectiveness of different formulations. A new spray system for applying low-volume applications was developed and evaluated and proved to be as effective as the minispin system used previously. Furthermore, the new system has no bearings to wear out.

In tests with aerosol generators used to disperse insecticides for adult mosquito control from the ground, thermal and non-thermal aerosol generators used to apply malathion, fenthion, and naled were equally effective in killing or controlling caged or natural populations of salt-marsh mosquitoes. Furthermore, water was as good as fuel oil as a diluent for these insecticides when they were applied from non-thermal aerosol generators. With thermal aerosol generators there was no differences in the degree of adult mosquito control when different oils were used as diluents.

Studies were conducted in cooperation with the Department of Defense in Thailand to evaluate the effectiveness of insecticides for the control of Aedes aegypti and Culex quinquefasciatus when applied as adulticides or larvicides. Fogging tests with six insecticides dispersed in fuel oil from a Swingfog pulse jet fogger showed fenthion, Bay 41831 and malathion to give highly effective control. Naled, Bay 39007, and Shering 34615 were also highly effective but required higher concentrations for effective control. As larvicides, Abate and Dursban applied at 0.005 lb/acre and fenthion at 0.05 lb/acre produced almost complete control of Culex quinquefasciatus larvae breeding in ditches and canals under houses. Abate and Dursban gave good residual control as larvicides for Aedes aegypti breeding in concrete water storage jugs.

In Florida resistance to malathion in salt-marsh mosquitoes has been found and confirmed in several counties.

Studies are still in progress to develop new insecticides that can be used as residual sprays where Anopheles mosquitoes have become resistant to currently used materials. In laboratory tests, ten chemicals were highly effective and will be evaluated further. Field tests were conducted in buildings in rice-growing areas in Louisiana naturally infested with Anopheles quadrimaculatus to evaluate a group of organophosphorus and carbamate chemicals as residual insecticides. Two materials - RE-5353 and Schering 34613 - were highly effective, causing 99-100% reduction of adults throughout a 15-18 week test period. Wettable powder formulations of two and emulsion concentrates of three other materials caused reductions of 98-100% on most occasions throughout the same period.

The studies on the use of flame-proofed cheesecloth impregnated with Bay 39007 continued. Treated cloth placed along the edge of the ceiling and in each corner from the ceiling to the floor of buildings containing natural infestations of Anopheles quadrimaculatus produced 98 to 100% control through at least 21 to 22 weeks of aging. On the basis of these successful tests, preliminary evaluations against Anopheles species in Nigeria were conducted in cooperation with the World Health Organization in 1965. Promising results were obtained and further tests are currently under way.

Research was continued at Corvallis, Oregon on the development of insecticides and the evaluation of insecticide resistance. Several new analogs of DDT were tested against Culex tarsalis, but none were highly toxic to resistant strains. Six identified chemicals from western red cedar were not highly toxic to Culex tarsalis, indicating that other compounds in western red cedar must be responsible for the toxicity. In pre-hatch treatments against snow-water mosquitoes, fenthion and Abate granules and benzene hexachloride wettable powder at dosages of 0.05 to 0.10 lb/acre gave 85% to 90% control. In post-hatch treatments granules of Dursban and Abate gave good control of 0.03 lb/acre. Dursban, as an emulsion in fuel oil, at 0.05 lb/acre gave good initial and 18 days' residual control of mosquito larvae in log ponds.

Under contract with the University of California research is underway to evaluate promising insecticides as larvicides and adulticides for irrigation water mosquitoes when applied as low-volume aerial sprays. The distribution and deposit of applications of low volume sprays have been compared to those obtained with conventional spray systems. Preliminary tests against mosquitoes indicate effective control of mosquito larvae with low volumes of organophosphorus insecticides.

2. House Flies (All livestock). At Corvallis, Oreg., basic research was continued on the mode of action of insecticides, mechanisms of insecticide resistance, and means of overcoming the problem of insecticide resistance. To study the genetics of insect resistance to insecticides, several mutants of the house fly were isolated from normal and gamma-irradiated strains reared in the laboratory. The genetic basis of the mutants was analyzed. Most mutants isolated involved wing form, wing positioning, wing venation, eye color or coloration. Four well established, genetically characterized mutant strains, classic wing, stubby wing, dot vein, and white have been extremely useful in studying the genetic basis of insecticide resistance. The resistance spectra of 8 insecticide resistant house fly strains were measured in tests with 15 insecticides. The insecticides included organophosphates, carbamates, chlorinated hydrocarbons, cyclodienes, and a botanical. Resistance to organophosphates and carbamates was associated primarily with fifth chromosomal altered esterase genes. Chlorinated hydrocarbon resistance was associated with fifth chromosomal semidominant genes for dehydrochlorination and second chromosomal recessive genes of unknown mechanism. Resistance to cyclodiene insecticides was associated with genes on chromosomes other than the second or fifth.

Research has been continued to develop synergists for organophosphorus and chlorinated hydrocarbon insecticides against insecticide resistant strains. In cooperation with the Pesticide Chemicals Research Branch a large number of candidate synergists are being synthesized or procured and tested.

A factor kdr (for knockdown resistance) conferring resistance to DDT and all other chlorinated hydrocarbons has been verified in 2 house fly strains. The fact that pyrethrins resistance may be due to the same factor suggested that pyrethrins synergists might block resistance associated with this factor. Studies to date have not borne out this assumption. Experimental work has failed to demonstrate a metabolic basis for resistance associated with kdr.

Considerable basic research has been developed on esterases in insecticide susceptible and resistant strains of house flies. Disc electrophoresis has been used attempting to separate and concentrate insect esterases. Considerable progress has been made in developing useful techniques and concentrating enzymes. Preliminary research indicates some differences between susceptible and resistant forms. However, considerable research is needed to isolate and study these enzyme systems.

An effort was made to control large populations of flies through the use of dichlorvos resin strips in the septic system and manure disposal wagon of a local slaughter house. A high degree of larval control was obtained. High larval infestations did not develop even though many egg masses were deposited. Little effect was noted on the adult populations since many flies were coming from other areas in the vicinity of the slaughter house.

A laboratory strain of the little house fly was shown to possess a dehydrochlorinative-type factor for resistance to DDT.

At Gainesville, Florida, the search for new insecticides effective in controlling house flies was continued. In laboratory tests, eight experimental insecticides were more effective than the ronnel standard against insecticide susceptible and resistant house flies. Residual tests against house flies in Florida dairy barns were conducted with eight emulsions and wettable powder formulations. Dimethoate residues were the most effective giving satisfactory control for 3 to 6 weeks. Dursban and Mobil MC-A-600 were effective for 1 to 3 weeks and Bay 41831 up to 2 weeks. The remaining compounds produced satisfactory control for less than 1 week and in most instances were ineffective at the 24-hour posttreatment evaluation. Tests were conducted with 19 selected insecticides against natural infestations of house fly larvae in manure under caged poultry to determine their effectiveness as larvicides. All chemicals were applied as emulsions or wettable powder suspensions at 100 mg/ft². Shell SD-8448 and SD-8802 gave slightly better control than the dimethoate standard. Other materials were inferior to the standard. None of the compounds tested gave effective control for more than 1 week.

Investigations of physical methods for controlling flies in dairy

operations were continued at Beltsville, Maryland as a cooperative effort of the Entomology, Animal Husbandry, and Agricultural Engineering Research Divisions.

A study was initiated to evaluate the effectiveness of farmstead sanitation practices in reducing fly populations and to determine whether efforts by individual farmers are beneficial, or whether concerted community action is essential. Monitoring surveys were made of native fly populations on neighboring farmstead areas and of the dispersal of marked flies released at various points within the area.

Removal of fly-attractive materials from a dairy complex appeared to reduce the house fly populations by about 1/3. Stable flies were not much affected by barn and corral cleanup. House flies dispersed more rapidly from areas with few breeding sites than from areas with many breeding sites and were more attracted to farms with uncleaned corrals and barns than to farms having daily manure cleanup. Most house fly dispersal occurred within 4 days after adult emergence and was quite rapid to farms within a 1 mile radius of the emergence site.

3. Screw-worm (All livestock except poultry). Of 30 new compounds screened for larvicidal effectiveness at 10, 1.0, and 0.1 ppm in screw-worm larval medium, 7 were highly effective killing all the larvae at 1.0 ppm. None of the compounds screened were effective at 0.1 ppm.

4. Stable Fly (Cattle and horses). Sixty-six compounds were evaluated as stable fly larvicides at Gainesville, Florida. Bayer 24498 and Stauffer N-3794 were better than the standard, Bay 39007. The candidate compounds had LC-50's of 0.62 ppm and 0.72 ppm respectively as compared to 0.94 ppm for Bay 39007. Other highly effective compounds were Bayer 29492, Bayer 48772, and Bayer 48792 with LC-50's ranging from 1.2 to 1.55 ppm.

Sixty-four chemicals were evaluated as stable fly adulticides in contact spray tests in a wind tunnel apparatus using Bay 39007 as a standard. Shell SD-8436 was about equal to the standard in effectiveness. Other promising chemicals were Niagara NIA-10242, Monsanto CP-7768, Niagara NIA-9227, and Shell SD-8448.

Field tests were conducted to compare the effectiveness of fenthion, naled, and malathion in controlling stable flies when these materials were applied by thermal and non-thermal aerosols. Tests were run against caged females with both aerosol generators calibrated to deliver 40 gallons of liquid/hr. Fenthion was slightly more effective than naled and both compounds were about 10 times more effective than malathion. There was no substantial difference in the kill of stable flies treated with thermal or non-thermal aerosols or between fuel oil and water-based formulations in the non-thermal aerosol generator.

A contract was negotiated with the Florida State Board of Health to conduct research on insecticidal methods of controlling stable flies (also called dog flies) under field conditions at their Panama City Research Laboratory. Initial field tests indicated that application rates of naled used as aerosol treatments for mosquito control did not give satisfactory kill of dog flies. Doubling the concentration of naled increased kill to 96%. Preliminary tests applying naled by aircraft at 0.14 and 0.07 pounds per acre gave good to excellent control and further tests are planned.

In Texas, 94 new compounds were screened on cattle in spot tests for repellency and toxicity against the stable fly. Nine of these compounds were class IV toxicants - namely, ENT 25655, 27109, 27300 a, 27324, 27341, 27350, 27382 and 27389. None of the materials tested were effective repellents.

In Texas, large cage tests were conducted to evaluate the effectiveness of various insecticides in backrubbers and as low volume sprays. Backrubbers treated with 1 and 2% ronnel gave only about 50% control of stable flies in 18 hour exposures. Of 12 materials applied at 0.5 - 1.0% at rates of 23 to 46 ml per animal, coumaphos was the most effective, giving complete kills for 3 days. Other materials such as Ciodrin, carbaryl and naled were not completely effective one day after application.

In Texas, seven new materials were evaluated as topical treatments and all gave 100% kill at 0.1 ug/fly, but only one (ENT 20738) was effective at 0.01 ug/fly.

In Texas, extensive tests were conducted to determine the effectiveness of Bakthane (*Bacillus thuringiensis*) as a feed additive for controlling stable fly breeding in cattle feces. The effectiveness of the soluble portion of Bakthane was greatly reduced in the feces after passage through the ruminant digestive system. The insoluble portion and the whole product were equally effective in preventing stable fly development in the feces.

In Texas, a number of materials were evaluated for toxicity to stable fly larvae. The materials were mixed with manure at different concentrations and larvae added periodically. The most toxic material was dimethoate, a concentration of only 0.5 ppm killing all introduced larvae for a period of 8 to 10 days. Malathion and Abate at 10 ppm were effective for only several days. In similar tests in Nebraska, Bioferm S5-440 was 100% effective at 1.0% and 99% effective at 0.1% but relatively ineffective at concentrations of 0.01% and lower.

5. Cattle Grubs (Cattle). Research was continued in Texas and Oregon, to develop more effective insecticides for the control of cattle grubs and other bots affecting livestock. In Texas, 79 new compounds were screened

for systemic action by giving them orally and subcutaneously at several dosages to guinea pigs infested with larvae of Cochliomyia macellaria and Phormia regina. Twenty-three materials showed systemic activity in one or both types of administration.

In Texas, over 40 systemics were tested for effectiveness against cattle grubs (H. lineatum) on small numbers (3-4) of government cattle. Four were effective in sprays, one in spray and in feed and one in pour on and in feed materials. In large scale tests on cooperator cattle 95 to 100% control of grubs in 4 herds was obtained with 1% sprays of trichlorfon and 8 and 16% pour ons applied at 1 and 0.5 ounces per hundred weight, respectively. Additional tests were conducted in Texas with 10 materials on cattle from Wyoming, which were infested with both species of cattle grubs (H. lineatum and H. bovis). Over 90% control was obtained with 3 materials as sprays, one in feed and one in spray, in feed and by injection.

In Oregon, field tests were conducted on cooperator's cattle to evaluate the effectiveness of Ruelene and Imidan sprays and pour ons of Imidan, Shell SD 8447 and SD 8436. Sprays of 0.375% Ruelene and Imidan gave 99 and 97% grub control respectively. In two tests Imidan pour ons (4 ounces of 1 lb/gal concentrate) gave 90 and 98% control. Other materials were ineffective at even the highest of 3 pour on dosages.

6. Horn Fly. In Texas, tests were conducted to evaluate 9 materials as feed additives for the control of horn flies. Dosages of 10 mg of Shell SD 8447 and Bromophos prevented horn fly larval development in feces. A comparison of the soluble and insoluble fractions of commercially produced Bacillus thuringiensis showed that feeding of the insoluble portion to cattle caused greater mortalities of dipterous larvae in the manure. The endospores and crystalline inclusion were then separated from the insoluble portion and given orally to steers. In tests against horn fly larvae, it was found that spores and inclusion bodies are responsible for a portion of the larvicidal effect. When manure was autoclaved after having been incubated 72 hours the larvicide was destroyed but this was not true for spore-containing manure.

In Texas, 12 materials were applied by sprayer at volumes of 23 to 46 ml/animal. A single application of coumaphos controlled horn flies for 7 days, whereas Ciodrin, carbaryl and naled were effective for only 1 day.

In Texas, pour on applications of 2% coumaphos, 2% fenthion, and 8% trichlorfon (and an 0.75% trichlorfon spray) provided effective control of horn flies for 7 to 13 days in humid coastal areas. Similar treatments were effective for about 21 days in semi-arid areas of Texas. In other field tests a 1% pour on and 0.5% spray of Shell SD 8447 was effective for only 1 to 2 weeks. Special studies were conducted to

determine the number of cattle in herds that should be treated to produce effective control of horn flies. It was found that treatment of one-half of herds gave practically 100% control in 24 hours and good control continued for a week despite heavy rains. Sprays of 0.25% Dursban gave effective horn fly control for about 10 days.

In Mississippi, extensive tests were conducted with several insecticides used in different ways for the control of horn flies. Light spraying in pens with 0.03 to 0.06% coumaphos, 0.25% trichlorfon and 0.025 - 0.1% fenthion gave effective control for about 5 days. Low volumes applied by automatic sprayer of 1.0% coumaphos controlled flies for a week but similar applications of 1.0% Hooker HRS 1422, 0.1% Dursban and 0.1% fenthion were effective for only about 5 days. Backrubbers treated with 0.25, 0.5 and 1.0% fenthion were equally effective for 15 days. Bags containing several insecticidal dusts were tested by placing them in shelters where the cattle would use them. Dusts containing 5% of fenthion, coumaphos or Bayer 9010 provided practically complete control of horn flies for over 4 weeks at which time the tests were terminated. A 0.5% dimetilan dust was effective only 3 weeks.

At Corvallis, Oregon, a study was conducted to evaluate the effectiveness of dust bags treatments of 1.0% dimetilan available to cattle on a free-choice basis for the control of horn flies. Dust bags were installed on a crossbar between two wooden uprights or trees in 5 different pastures located in Corvallis or Summer Lake, Oregon. Results showed successful horn fly control can be attained under certain conditions by the use of free-choice dust bags. Control was excellent in 4 out of 5 herds. In two of these herds dusting on some animals and loss of dust from the bags was considered excessive.

7. Face Fly (Cattle and horses). In Nebraska, extensive bioassay tests were conducted to compare the effectiveness of two Bacillus thuringiensis products against face fly larvae. The products were essentially equal in effectiveness, with both causing complete larval mortality at a concentration of 1.0%. A concentration of 0.1% allowed 25 to 40% of larvae to survive and pupate but no adults emerged from the pupae. Lower concentrations were ineffective.

8. Ticks (Cattle and horses). At Kerrville, Texas, ears of cattle were treated with various formulations and concentrations of 23 insecticides, some of which had been tested the previous year for the control of spinose ear ticks. The effectiveness of the treatments was determined by comparing the numbers of ticks scraped from ears of treated and untreated cattle at 1 week and 1 month posttreatment. Practically all of the insecticides except Dri-die provided a high degree of control at 1 week posttreatment, but only 5% coumaphos dust and 0.1% emulsion of Compound 4072 afforded 100% control of nymphs at 1 month posttreatment.

During the summer of 1965, 3 tests were conducted at Camp Stanely with 2-year-old Hereford heifers naturally infested with lone star ticks to evaluate the efficacy of insecticidal sprays in controlling these ticks. Dursban, bromophos, Shell SD-8447 and 8448, Bay 37341, carbaryl, trichlorfon, Bay 39007, Dowco-175, Banol, and Imidan were applied to cattle at various concentrations in different formulations (1 gal/head) and the effectiveness in controlling lone star ticks was compared to a standard 0.5% toxaphene spray. All insecticides except bromophos (0.375%) and Bayer 37341 (0.1%) were as effective as toxaphene (0.5%) at 1 day post-treatment. A 1 week posttreatment, those treatments affording control equal to or greater than 0.5% toxaphene were: 0.25% Imidan, 0.1% Shell SD-8448, 0.1% Dowco-175, 0.25% Bay 39007, 0.5% Shell SD-8447, 0.1% Dursban, 1% trichlorfon, and 0.5% carbaryl. At 2 weeks posttreatment none of the insecticides gave more than 20% control.

Personnel of the Kerrville, Texas, laboratory continued research on the evaluation of insecticides for the control of Boophilus ticks on cattle. Several hundred candidate toxicants were screened for effectiveness against Boophilus annulatus and/or Boophilus microplus. About 50 compounds proved highly effective when these ticks were dipped in solutions of emulsions of these toxicants. Materials considered highly effective where those that reduced egg laying or egg hatch by at least 90%.

Extensive field tests were conducted in Mexico, to evaluate the effectiveness of promising insecticides as sprays and dips for the control of Boophilus ticks on cattle. Sprays of 0.1% Banol; 0.5% carbaryl; 0.05% carbophenothion; 0.3% Ciodrin; 0.25% coumaphos; 0.15% dioxathion; 0.01% to 0.1% Dursban; 0.03% to 0.25% Imidan; and 0.1% - 0.45% Shell SD-8447 gave 94% to 100% control of reproduction. Imidan, Dursban, coumaphos, and carbaryl gave complete control of reproduction of one or both species of Boophilus ticks tested. Dipping trials with Dursban and Imidan showed high or complete control of reproduction.

At Corvallis, Oregon field tests were conducted on the effectiveness of three insecticides in controlling ticks, Dermacentor andersoni, on cattle. Newer insecticides were applied to animals as whole body sprays. Toxaphene was applied as a whole body spray and also in a more concentrated form to the tick infested portion of the neck and brisket only. The new materials - Compound 4072 and Ciodrin - gave 82% to 84% control after one week. Whole body sprays of toxaphene were less effective in controlling ticks (89% reductions after 1 week and 0% reduction after 2 weeks) than the more concentrated application applied to the neck and brisket only (97% to 100% reduction after one week, 74% to 97% reduction after 2 weeks, and 29% to 55% reduction after 3 weeks).

9. Ticks (Poultry). In tests at Kerrville, Texas, dust boxes treated with Zytron or Dowco-175 granules had no effect on the numbers of fowl ticks present on infested white leghorn hens.

10. Mites (Poultry). At Corvallis, Oregon several insecticides were bio-assayed with the Hanson strain of the northern fowl mite using a topical application method. The Ld-50's were determined as 0.0005% concentration for Shell SD-8447, 0.0033% for Abate, and 0.0072% for malathion.

11. Lice (Poultry). Research on the development of insecticides for the control of poultry lice was continued at Kerrville, Texas. Eighteen selected toxicants were evaluated for poultry lice control by treating birds with acetone solutions of the technical grade chemical at the rate of 40 ml/bird. Seventeen of the candidate toxicants eliminated lice from the birds within 3 to 7 days when applied at spray concentrations of 0.05%, 0.1%, or 0.25% and birds remained free of lice for at least 14 to 28 days. In another test, control of poultry lice by the use of dry insecticides mixed with sand in "dust boxes" was evaluated. One-half pound of granules containing 4.4% Zytron per box reduced lice populations but did not completely eliminate them. In a similar treatment using one pound of granules containing 1% Dowco-175 per box little reduction in numbers of lice occurred.

12. Lice (Sheep and goats). At Kerrville, Texas, Angora goats heavily infested with biting lice were sprayed with Imidan at concentrations of 0.05%, 0.1%, and 0.25%. At 1 day posttreatment some goats in all groups had live lice. At 1 week posttreatment no live lice were found. Four months later at the next shearing all animals were moderately, to heavily infested with lice. Three weeks after shearing, the same goats were sprayed with 0.05%, 0.10%, and 0.25% Shell SD-8447. Live lice were found on goats sprayed with the two lower concentrations at 1 day posttreatment and by 1 month infestations were again moderate. With the 0.25% spray, no live lice were seen 1 day posttreatment and very few lice were found 1 month after treatment.

On three ranches in Kerrville, Gillespie, and Kimble counties sheep moderately to heavily infested with biting lice were treated with insecticides for louse control. At 4 to 6 weeks after treatment, 0.5% DDT and 0.125% coumaphos afforded complete control; 0.05% Dursban afforded 95% control, and 0.25% Shell SD-8447 and 0.5% carbaryl afforded 70-75% control.

C. Biological Control

1. Mosquitoes (All livestock). At Lake Charles, Louisiana, research on mosquito pathogens as potential biological control agents has been increased. Microsporidian, bacterial, fungal, viral and/or nematode parasites have been found in 35 species of mosquitoes in Louisiana. Microsporidian parasites have been found in about 17 species of mosquitoes including infections of Thelohania, Stempellia, Plistophora and Nosema. Microsporidian parasites have been grouped according to host parasite relationships described by Kellen and co-workers. Transovarial transmission has been demonstrated. Most infections found in field populations of mosquito larvae tend to be of a low order (around 1%). Means and methods of increasing infectivity need to be developed. Corothrella appendiculata,

a very small chaoborid which inhabits tree holes and artificial containers, was observed to be infected with an unknown species of microsporidia. A colony of Culex salinarius infected with Thelohania has been established in the laboratory for experimental purposes. Since only adult females survive from infected egg rafts it is necessary to add males from a non-infected colony to keep the infected colony going.

A species of Spirillum (a bacteria) which invades the hemocoel has been isolated from 12 species of mosquitoes. Infection rates are generally low in field populations. For example, approximately one percent of Culex p. quinquefasciatus collected from a roadside ditch polluted by septic tank effluent were infected.

Coelomomyces infections have been identified in eight species of mosquitoes. An infected colony of Culiseta inornata has been established for laboratory studies and a naturally infested pothole in the field is being studied.

A virus has been identified in Aedes sollicitans, A. taeniorhynchus and A. vexans. A colony of A. taeniorhynchus infected with this virus is being maintained for basic studies of infectivity within and between different species of mosquitoes. Nematodes and internal ciliates have been identified in several species of mosquitoes.

Colonies of Culex p. quinquefasciatus, C. salinarius, Aedes triseriatus, and Culiseta inornata are well established in the laboratory for basic research on biology and pathogens.

At Corvallis, Oregon, research was initiated on microsporidian infections of mosquitoes found in log ponds. Infections were found in Culex pipiens, Culex peus and Culiseta incidens. A technique for determining per os transmission has been developed; however, methods of transmission other than transovarian have not been demonstrated.

At Gainesville, Florida, research on pathogens of mosquitoes has been increased. Microsporidian parasites have been found in Culex salinarius, C. restuans, Anopheles quadrimaculatus, and A. crucians. It has been impossible to infect healthy larvae with these parasites so research has been initiated to elucidate life cycle and biology of the parasites. Fungi of the genus Coelomomyces and Achlya have been isolated from several species of mosquitoes as well as several species of bacteria. A microsporidian has been found infecting a species of chironomid.

Under contract with the Fresno Laboratory of the California State Public Health Department through the University of California at Berkeley is researching pathogens as biological control agents. Various species of bacteria -- Bacillus cereus, B. thuringiensis, B. sphaericus, Aeromonas hydrophila, Pseudomonas sp., Flavobacterium sp., and Achromobacter sp.; fungi -- Spicaria farinosa and Coelomomyces psorophorae; microsporidia:

and viruses have been identified as pathogens in western species of mosquitoes. Host-parasites relationships and methods of infectivity are now under study.

Under contract funds with the McNeese State College at Lake Charles, Louisiana research is being conducted on predators of mosquito larvae. Studies are in progress on insects and fish as predators of mosquito larvae and have included Mollienesia latipinna and Cyprinodon variegatus and species of the family Corixidae. Some observations indicate corixids may lay their eggs on crawfish. This is of special interest in relation to Psorophora confinnis in Louisiana rice fields where many owners are alternating between rice and crawfish crops.

2. Houseflies (All livestock). A grant with the University of California has been negotiated to study the effect of predacious mites on populations of flies breeding in manure. Progress to date has been limited to identifying mite species and determining density of mites in various fly breeding sites.

A PL-480 project in Korea is making excellent progress in identifying species of beetles present in dung and defining their role in the dispersion of dung with related effects on fly breeding. Progress to date is mainly in determining species, their distribution, biology, and life cycles.

3. Imported Fire Ant (All livestock). Under PL-480 support, research was continued on parasites of the imported fire ant in Uruguay. The distribution of imported fire ant colonies has been studied and recorded. Data has been collected on various forms of arthropods found in ant mounds. Of particular interest have been studies on an ant, Labauchena daguerri, which parasitises the imported fire ant. Laboratory and field studies have shown that L. daguerri is apparently dependent upon the imported fire ant for survival and weakens imported fire colonies in the field.

4. Face Fly (Cattle and horses). At Lincoln, Nebraska, adults of Aleochara tristis, a European parasite of the face fly, were received early in 1965 and successfully colonized in the laboratory. Between May 24 and August 19 over 40,000 adults were released in 40-acre pasture occupied by a small herd of cattle. Parasitized face fly pupae were found in 15 days after the first adults were released. Peak parasitism of about 12% obtained during late July and early August declined rapidly thereafter to zero by late August. Parasitized pupae were recovered up to 1 1/4 miles from the release pasture within 2 months after adult releases started.

Extensive tests were conducted to study the behavior of A. tristis under laboratory and field conditions. It was found that the newly

hatched tristis larvae preferred 3- and 4-day-old face fly pupae to those 1-and 2-day-old, but parasitism was relatively low even with favorable ratios of larvae to pupae. In host preference studies with other species of dipterous pupae, face fly were preferred over other species. However, in the absence of the face fly, pupae of Orthellia caesaviane were more acceptable than other dipterous pupae, with house flies being next in order. Very little parasitism of the stable fly (Stomoxys calcitrans) and the horn fly (Haematobia irritans) occurred.

Laboratory tests in Nebraska showed that larvae and pupae of A. tristis cannot survive 1-week exposure to temperatures of 10° to 20° F. Survival was good for 1 to 2 weeks at 45° to 50° F but poor after 4 to 5 weeks, and good for 3 weeks at 55° F but only fair after 5 weeks. Old pupae survived 45° to 55° F storage much better than maturing larvae and young pupae. However, under field conditions adult tristis survived in good numbers over winter despite the lack of snow and minimum temperatures of 18° F.

In course of field studies on A. tristis another similar appearing species, A. bimaculata, was discovered and found to be parasitizing several species of Sarcophaga and Orthellia but only rarely the face fly. The habits of bimaculata are similar to those of tristis.

In Nebraska adult face flies were observed to hibernate in the same barns for the fourth consecutive year. First hibernation was noticed on Sept. 25 and calculations suggest hibernation may be related to average daily temperatures below 65° F. No adult flies or larvae were noted in the field after mid-October.

D. Insect Sterility and Other New Approaches to Control

1. Mosquitoes (All livestock). At Gainesville, Florida, research was continued on the evaluation of the sterility principle for control of mosquitoes. The effect of varying dosages of gamma radiation on fecundity and fertility of Aedes aegypti treated in the pupal stage was determined. Females were completely sterilized at 3,000r, while males were completely sterilized at 10,000r. Male Culex p. quinquefasciatus were almost completely sterilized at doses of 7,000 to 12,000. Males irradiated at 8,500 and 10,000r were less competitive than untreated males in mating. Males of C. p. quinquefasciatus were effectively sterilized by dusting with apholate powder. The sterility induced was permanent and the sterilized males were competitive with untreated males in mating untreated females.

Two sterile male release studies were made with a semi-isolated population of Anopheles quadrimaculatus. Males were sterilized by exposure to

residual deposit of tepa. Although some sterility was induced in the natural population (up to 42%), no reduction in the numbers in the population occurred. A bait of apholate was placed in natural resting stations of A. quadrimaculatus in this same area in another experiment. Although a high degree of sterility occurred in mosquitoes feeding on the bait, there was little sterility in the natural population and no reduction in its size.

The colony of Aedes aegypti which developed resistance to apholate through laboratory selection is being maintained. Previously reported resistance was confirmed and the level has continued to increase. Tests indicated that this apholate-resistant colony was not resistant to tepa. Studies have been initiated to determine the mechanism involved in resistance to apholate.

2. House Flies (All livestock). Research was continued at Gainesville, Florida, on the development of sterilization techniques for house fly control. Six hundred and thirteen chemicals were screened for chemosterilant activity and 67 of these caused complete sterility in adults. Twenty-five of the chemicals also caused complete sterility in males. Tests were conducted to determine whether chemicals causing sterility in house flies affected sperm motility. All of the chemosterilants found in screening tests to date were evaluated and none had any effect on sperm motility. One hundred and seventy two chemosterilants were evaluated for sterilizing effects when they were applied to house fly rearing medium containing third instar larvae. Eleven of these chemicals caused complete sterility by preventing oviposition or egg hatch. House fly pupae immersed in solution of hempa or 2,4-diamino-6-(2-furyl)-s-triazine for periods of 5 to 30 minutes were sterilized. However, the sterilizing dose was probably acquired mostly through adult contact with treated pupal cases during emergence since washing pupae after treatment reduced sterility to low levels (35% to 46%). Hempa caused a reduction in cholinesterase activity in in vivo and in vitro tests with house flies.

Tests were conducted on Grand Turk Island in the Bahamas to evaluate the effectiveness of an integrated program for the control of house flies. The approach consisted of making insecticide and chemosterilant applications to larval breeding sites as well as releasing adult flies that had been sterilized by gamma irradiation. High population reductions were achieved through the application of larvicides and chemosterilant baits and there was a high degree of sterility in the population of house flies remaining on the island. The release of sterile insects appeared to increase the level of sterility in the natural population but did not cause sufficiently to eradicate the population. Either the number of sterile insects released was too low or their behavior and dispersion was abnormal. Research has been undertaken to study dispersion of released house flies on the

island and the density of the natural population existing on the island. House fly populations were reduced in numbers by the integrated control scheme to approximately 1,000,000.

At Corvallis, Oregon, research was undertaken on methods of sterilizing the little house fly. Tapa, metapa, apholate, hempa, and hemel were evaluated in the laboratory as chemosterilants. Residual treatments of tapa 0.1-1.0 mg/ft² sterilized these flies. Metapa and hempa were somewhat less effective, and apholate failed to sterilize at 50 mg/ft.² When fed to adult flies, tapa was again the most effective, producing a high degree of sterility at concentrations of 0.01 to 0.1% in adult food. The other materials were about equally effective. In experiments on mating competitiveness, males treated with hempa and metapa competed well with untreated males. There was no great margin between dosages causing complete sterility, especially of females, and those causing some mortality. Pupae were unaffected when dipped in 0.05 to 5% ethanol solutions of metapa.

3. Screw-worm (all livestock except poultry). Of 646 compounds screened as chemosterilants, 29 caused sterility in 1 or both sexes of screw-worm flies when fed to adults. Evaluation of chemosterilants passing screening tests showed that some compounds sterilized also when administered as topical treatments, some sterilized only 1 sex, and some sterilized both male and female flies.

Additional tests were performed with 3 chemosterilants (ENT-50838, 50716, 50781) previously reported to equal or surpass radiation in their effectiveness in achieving sterility of screw-worm flies. In test of sexual aggressiveness of males, harassment of females by chemosterilized males was very nearly equal to that by untreated males. In other tests, chemosterilized males survived at least 90% as well as fertile controls.

ENT-50781 effectively sterilized males 0-1, 3-4, or 6-7 days old. Sterility of females 0-1 day old was high, but that of females 3-4 and 6-7 days old was complete, or nearly complete. Males offered ENT-50781-treated food for 16 hours were nearly sterile. Sterility after 20- and 24-hour intervals was equal and essentially complete. Males treated orally with ENT-50781 were ground, extracted with chloroform, and fed to new males. Enough active chemosterilant was recovered to give rise to moderate and slight sterility 24 and 72 hours, respectively, after treatment.

Tests were conducted to find methods of administration of ENT-50838 other than oral or topical treatments of adults that were effective. ENT-50838 sterilized when pupae were immersed in solutions and the emerging flies were in contact with the residual chemosterilant on the shed puparia for more than 48 hours. Complete sterility was induced in males by tarsal contact for 4 hours with a residual deposit of 20 mg/ft² of ENT-50838 on glass. The deposit was moderately effective after 2 weeks and ineffective after 5 weeks.

In tests of mating competition in a laboratory room, males sterilized topically by ENT-50838 were at least as competitive as untreated males. However, males sterilized by tarsal contact competed for females about half as well as untreated males.

Untreated males or females acquired the chemosterilant and a consequent high degree of sterility by bodily contact with flies of the opposite sex treated topically 5 days earlier with ENT-50838. However, males treated by injection did not transfer the chemosterilant by contact to previously mated females 5 days later.

ENT-50838 topically sterilized both sexes 0-7 days old essentially with equal facility. Males treated topically with ENT-50838 showed no loss of sterility 3 weeks later. There was no recovery from sperm damage induced 48 hours earlier in 5-day-old males injected intrathoracically with ENT-50838. It was found that incompletely sterile populations of males were composed of some males with 100% dominant lethals in the sperm and others with fewer than 100% dominant lethals. ENT-50838 was equally effective in topically sterilizing virgin and mated females.

Other chemosterilants were also tested. ENT-51086 did not greatly affect male sexual vigor adversely in tests of sexual aggressiveness of males. However, it adversely affected the mating vigor of males by a factor of about 1.5-2.0 in tests of mating competition. ENT-50451 applied topically induced dominant lethals equally well in sperm prior to ejaculation and sperm stored in spermathecae.

A possible basis for the preferential action of some chemosterilants according to mode of administration was sought. A blood pH of 6.0-6.8 and a mid- and hindgut pH of >4.7 - >7.0 might explain the greater vulnerability to degradation of some aziridiny compounds, which are acid-sensitive, by the oral than the topical route.

4. Stable Fly (Cattle and Horses). In Texas, exposure of stable flies on deposits of 10 to 375 mg/ft² failed to induce complete sterility. In additional tests, topical application 0.125-30 ug/fly of tepa gave almost complete sterility of males but they were slightly less competitive in mating than normal flies. The treatments did not appear to reduce fecundity in crosses with untreated females.

In Texas, studies were conducted on the mode of action of the chemosterilant, apholate, on stable flies. Preliminary studies using radioactive Thymidine indicated an interference in young stable flies of the synthesis of DNA by apholate. The interference appeared to be in the incorporation of Thymidine into the primordial egg cells.

5. Horn Fly (Cattle). At Kerrville, Texas, research was continued on the development of new methods for the control of horn flies on cattle. An electro-chemical device was developed which provided effective control of

horn flies and completely avoided the risk of contamination of the cattle, milk or milking equipment. The device uses BLB ultraviolet fluorescent lamps installed behind insecticide impregnated gauze. Horn flies are attracted to the light, contact the treated gauze and die in a few minutes. When operated during total or semi-darkness these devices reduced larvae horn fly populations by 90 to 95% within 7 to 10 days and maintained effective control thereafter. Additional studies are planned to determine the efficacy of covering entrances to barns to create a semi-darkness environment in which the units would be effective at all hours of the day.

6. Tsetse Flies. Under a PASA agreement with AID research was continued in Salisbury, Rhodesia in cooperation with the Agricultural Research Council of Central Africa on the feasibility of the sterile male technique for control of tsetse flies. Following successful research developing effective methods of chemosterilizing 2 species of tsetse, Glossina morsitans and G. pallidipes, field tests have shown that sterile males are competitive with normal males in small cage tests and that sterile males disperse and survive as well as normal males under natural field conditions. An island has been selected for a small field experiment on the release of sterile males. Approximately 9-months data has been accumulated on population levels, dynamics, survival and birth rates to serve as a basis for designing a release experiment. Progress had been made in attempts to develop techniques for establishing self-sustaining colonies of tsetse in the laboratory or in cages in field environments; however, a productive self-sustaining colony for use in a release experiment or program has not been developed to date.

E. Insecticide Residue Determinations

1. Residue studies. In Texas further studies were conducted to determine the residues in animal tissues produced from contact with back rubbers treated with ronnel. Analyses have been made previously of ronnel residues in body tissues of cattle following use of a home-made back rubber constructed by covering a chain with several piles of burlap. A new type of back rubber is now on the market consisting of a stainless steel cylinder about 4 inches in diameter and 10 feet long, suspended in a horizontal position about 3 1/2 feet from the ground, with a strip of heavy cotton cloth attached to the bottom of the cylinder. The cylinder is filled with an oil solution of the insecticide, which escapes through holes in the underside to keep the suspended cloth saturated. Since this appeared to disperse more insecticide than the back rubbers used in earlier tests, determinations were made of ronnel residues in body tissues following the use of the new device. One group of eight cattle were allowed to use a back rubber charged with a 1% solution of ronnel, and another similar group with 2% solution. One control animal used a back rubber charged with the oil solvent only. The animals were forced to walk under the rubbers four times daily for 28 days. Since the earlier tests had shown that residues of ronnel were preponderantly in the fat,

the only tissues analyzed in this test were the renal and omental fat. The amount of ronnel found in the fat after 2 weeks use of the back rubber ranged from 0.006 to 0.031 ppm and after 4 weeks use the range was 0.008 to 0.097 ppm. Two and three weeks after the back rubbers were removed there was no ronnel detectable in the fat except for one animal in which 0.001 ppm was found two weeks after removal.

In Texas a study was made to determine whether small amounts of nonachlor in the feed of dairy cows would cause contamination of the milk. A Holstein cow was fed 2 ppm of nonachlor in its feed for 14 days. Milk samples were collected at intervals during the feeding period and after feeding had ceased. During the feeding of nonachlor the amount of residue found in the milk rose to a maximum of 0.255 ppm (milk adjusted to 4% butterfat). Ten days after feeding had ceased the residue had fallen to 0.022 ppm of nonachlor in the milk. Since residues had not yet been completely eliminated, additional samples were taken for analysis to determine the time required for complete elimination of the nonachlor.

In Texas analyses were made of the omental, renal, and subcutaneous fat of cattle following a single spray or dip treatment with 0.05% Dursban. Five weeks after treatment, the fat of the cattle that had been dipped contained from about 0.001 to 0.007 ppm of Dursban, while the fat of cattle that had been sprayed contained 0.001 to 0.003 ppm. Analyses also were made of fat from cattle that had received three dippings at 2-week intervals in 0.05% Dursban. Ten weeks after the last dip the Durshan residues in the fat ranged from 0 to 0.002 ppm. Another study was made to determine the residues in various body tissues one week after a calf that had been sprayed with 0.25% Dursban. The amounts found in the various tissues were muscle 0.007, liver 0, heart 0, kidney 0.002, brain 0.002, omental fat 0.60, renal fat 0.67, and subcutaneous fat 0.71 ppm.

In Washington extensive residue studies were conducted of plants in the Burns Tussock Moth Project area where DDT had been applied by helicopter at the rate of 0.75 lb/ acre. Residues calculated on a dry-weight basis were as follows: Sedge 9.3 to 261 ppm DDT (average 69), lupine 44 to 220 ppm (average 88), sagebrush 25 to 143 ppm (average 56). Four months after the application of DDT had been made vegetation samples were again taken and analyzed with the following results (dry-weight basis); sedge 5.2 to 22 ppm (average 13), lupine 3.2 to 17 ppm (average 13), sagebrush 3.2 to 12 ppm (average 5.9). Samples of fish and aquatic invertebrate organisms also were obtained from within the treated area and analyzed for DDT and its metabolites. The invertebrate pretreatment sample (from a creek bottom) had a residue of 0.9 ppm and another (a drift sample at the mouth of a creek) contained 101.0 ppm of DDT. Fish samples collected in June and July from the area sprayed in May and June contained residues ranging from 0.14 to 2.1 ppm. Adipose tissue of cattle from the Tussock Moth Control area also was analyzed for DDT

and its metabolites. The cattle were sampled in the fall following the spring treatment. Pretreatment samples of the adipose tissue showed from 0.02 to 4.4 ppm of combined DDT and its metabolites. The range and average of combined DDT and its metabolites found in the samples taken in the fall from cattle in several states in the area were as follows: California 6.3 to 16 ppm (average 12), Idaho 12 to 86 ppm (average 44), Oregon 1.7 to 7.7 ppm (average 5.2). Forty water samples were also collected and analyzed for DDT and its metabolites. Pretreatment samples showed no indication of DDT or metabolites. Twenty-eight samples of water from the treated area contained residues of < 0.1 to 0.2 ppb of o,p'-DDT and <0.2 to 0.7 ppb of p,p'-DDT. Three samples from the treated area contained 0.2 to 0.7 ppb of o,p'- and 0.7 to 3.6 ppb of p,p'-DDT. Neither DDE nor TDE was detected in any of the samples. One sample from an area where insecticides had been spilled contained a residue of 3.5 ppb o,p'- and 19.0 ppb p,p'-DDT. This work was in cooperation with the Forest Service.

In Texas a dairy cow was dipped twice with a one-week interval, in a 0.22% solution of As_2O_3 . Milk samples were taken for analysis from 1 to 14 days after the last dipping. The arsenic residues found in the samples one day after dipping amounted to 0.02 ppm; by the 10th day after the last dipping the residues were no longer detectable. Beef cattle were similarly treated and animals were slaughtered and tissue samples taken for analysis 2, 3, 4, and 7 days after the last treatment. Analyses are being made of various tissues and organs from these animals.

In Texas, analyses were made of omental fat samples from beef cattle at weekly intervals after they had been dipped in 0.22% ronnel emulsion. Fat samples taken after 1 week showed about 0.1 ppm. Residues declined to 0.002 ppm after 3 weeks and none were detectible after 4 weeks. Further studies were made to determine the residues produced by feeding ronnel to cattle at the rate of 8.76 mg/k per day for 14 days. The average residue at the end of the feeding period was 6.6 ppm. Residues decreased to only 0.011 ppm in 21 days and had completely dissipated in 35 days. In another test, residues were determined in cattle that had access (free choice) for 11 weeks to a mineral supplement containing 6% ronnel, 75% salt, and 19% other materials. The average intake of ronnel over the 11-week period was 4.1 mg/kg/day. Analyses showed an average residue of 0.89 ppm at the end of the feeding period. Low but detectible residues were still present in some but not all samples after 35 days.

In Texas, studies were conducted by veterinarians of the Animal Disease and Parasite Research Division to determine residues in the omental fat of sheep that had been dipped weekly for 9 weeks in 0.5% bromophos emulsion. Fat samples taken 1 day after the last dipping contained from 5.0 to 14.0 ppm. Residues of 0.07 to 0.43 ppm were still present 22 days after the final treatment.

2. Toxicity studies. Research was continued in Texas in cooperation with veterinarians of the Animal Disease and Parasite Research Division on the acute and chronic toxicity of insecticides and other chemicals to livestock.

Tests were conducted to determine the effects of single treatments of 15 insecticides on the plasma tocopherol levels in calves. No positive trends were noted other than a general depletion with passage of time. Fourteen of the insecticides caused no outward symptoms of poisoning at the initial concentration tested. However, four proved highly toxic at the highest of two test concentrations.

Studies were conducted to compare the effects of four chemosterilants on poultry. Chickens given 10.0 mg/kg orally daily of tepa or metapa became moribund and were destroyed after 24-32 doses (cumulative totals of 126-190 mg/kg/bird). All birds showed a marked loss in weight, ataxia and a characteristic squatting position when at rest. At necropsy the livers were friable and fatty degeneration was evident. The spleens were small and pale and the lungs were congested.

Chickens given daily doses of 5, 10, or 20 mg/kg of apholate or 50 mg/kg of hempa showed no signs of poisoning after 41 doses. At necropsy the livers, spleens and testes of the apholate-treated birds were smaller than normal but no gross lesions were noted.

Extensive studies were conducted to determine the toxicity of Abate to sheep and cattle. Sheep consuming from 1.9 to 2.9 mg/kg daily in water (20 times normal expected consumption) showed no ill effects and only slight ChE depression after 109 days. Cattle consuming 1.1 to 1.4 mg/kg showed no clinical evidence of damage after 4 months but ChE was reduced to 67-79% of normal.

Several series of tests were conducted to determine the toxicity of parathion to sheep. Dipping in 0.005% parathion caused no toxic symptoms but some of the sheep sprayed with 0.01 and 0.025% exhibited moderate to severe effects and a few animals died. Sheep tolerated and consumed feed containing 50 ppm of parathion without ill effects for 21 days and ChE was not greatly depressed. Sheep on feed containing 100 ppm of parathion were not visibly poisoned but their ChE was lowered to 22-47 percent of normal.

In tests with phosdrin, dermal applications of 0.05% caused no toxic symptoms to sheep and a concentration of 0.025% had no ill effects on cattle, but ChE was depressed in both kinds of animals. Oral doses of 5 mg/kg to sheep and 0.5 mg/kg to cattle caused no toxic symptoms but reduced ChE moderately. A few of many sheep sprayed with 0.25 or 0.5% carbophenothion were visibly poisoned but the majority exhibited no ill effects despite marked reduction of ChE. None were affected by 0.1% dips.

In Texas as in previous years a large number (over 60) new candidate insecticides were tested for toxicity to cattle, calves, and sheep when administered orally or dermally as sprays or dips. Toxicities ranged from impossibly dangerous to reasonably safe. Several of the safer materials posses excellent insecticidal activity and further studies will be undertaken to relate this to a safer dosage for possible practical control use in the event of registration for use on livestock.

F. Attractants.

1. Screw-worm (All livestock except poultry). In Texas 211 chemicals were screened as screw-worm attractants. Of these, 8 were found to compete with the standard liver bait. However, further evaluation eliminated all but ENT-5963 and ENT-28236. These compounds have received limited field tests but further testing is required as the data acquired from these tests are inconclusive.

The male screw-worm pheromone extract has been fractionated by Pesticide Chemicals Research Branch and the active material has been concentrated. Virgin female flies responded to this material even when it was diluted 200 times. In order to facilitate the identification of this material, a change in collecting technique was initiated in the hope that the number of extraneous materials in the extract could be reduced. The male pheromone was collected by passing the air from the cage containing males over activated charcoal. Hexane extracts of the charcoal have produced the same type of response by unmated female flies as that observed when they were exposed to the male pheromone extracts collected by the cold trap method. Both "searching motions" and aggressive male-type mating "strikes" were discerned.

Studies on the response of female screw-worm flies to selected odors revealed that habituation or a permanent waning of a response without reinforcement occurred in this insect. The most vigorous response occurred during the initial exposure period of 15 minutes. The response declined thereafter with little or no response being observed after test periods of 45 minutes. Tests made after periods of recovery where the odor was removed and then re-exposed to the flies determined that at least 2 hr was needed between experiments. After this period of time had elapsed, the flies responded almost as vigorously as they did in the first test period. Studies on the effect of temperature on the response of screw-worm flies to odors established that 64° F was the temperature threshold of response. No fly activity was observed at lower temperatures.

2. House Flies. At Gainesville, Florida, a method was developed to screen various chemicals as attractants (olfactory stimulation) for house flies. Various tests showed that edamin could be used as a standard, although its ability to attract flies is minimal. Of 113 chemicals that have been screened none have shown a high degree of attractancy.

Certain chemicals produced an anomaleus avoidance or repellency response.

Tests were run on certain chemosterilants to determine if they were repellent to house flies. Apholate was somewhat repellent; metapa and hempa may be considered highly repellent. Hempa did not attract or repel house flies by olfaction so that repellency may be tactile or gustatory.

Other tests showed that the age or condition of ovaries influenced the responsiveness of female house flies to ammonium hydroxide. Response differed with differing concentrations and a concentration of 1.0 N ammonium hydroxide was preferred over all other.

Research was continued on the sex pheromone reported earlier in the house fly. Considerable emphasis has been given to cooperative work with chemists of the Pesticide Chemicals Research Branch attempting to isolate active components or fractions of the pheromone. Isolation has not been accomplished to date. It was confirmed that the presence of the pheromone in female flies was age related. No house fly sex pheromone-like activity was present in benzene extracts of female or male black blow flies, female false stable flies, female or male stable flies, or female or male little house flies. To date clear demonstrations of activity have been observed only with extracts of female and male horn flies, and female house flies.

Approximately 90 miscellaneous compounds were screened as attractants for the little house fly in field tests near natural populations. None of the compounds showed an attraction of these flies or other muscid, calliphorid, and sarcophagid flies in the area.

G. Insect Vectors of Animal Diseases

1. Anaplasmosis (Cattle). In 1965, tests in Mississippi were designed to reflect the importance of horse flies and mosquitoes as vectors of bovine anaplasmosis. A group of 3 susceptible and 1 carrier animals were exposed continuously outdoors to attack by horse flies and mosquitoes. A similar group was exposed in a screened cage which excluded horse flies. Two of the 3 susceptible animals in the continous exposure test developed anaplasmosis and the other was a suspect, whereas none of the caged animals developed the disease. Similar additional groups of animals were used.

As a part of the anaplasmosis studies, the seasonal incidence of horse flies and mosquitoes was studied by means of animal baited traps, collection from bait animals, and direct counts on test animals. Animal baited traps operated from 5:00 PM to 7:00 AM (May 21-July 27) yielded over 17,000 mosquitoes of 14 species, with Psorophora confinnis composing 60% and Anopheles quadrimaculatus 25%. Only 300 horse flies were

captured with T. vittiger schwardti, T. fuscicostatus, and T. lineola, composing 66%, 14%, and 14% respectively. Peak populations occurred in late May and early June. Similar animal traps operated from 7:00 AM to 5:00 PM caught very few (199) mosquitoes, 70% of which were A. quadrimaculatus. Only 400 horse flies were captured, 80% being vittiger schwardti and 13% lineola.

Collections from a tethered bait horse and steer totaled about 5,000 on each animal, with peak abundance occurring late in May. Both collections were composed of about 75% vittiger schwardti, 8% lineola, 4.5-7.0% fuscicostatus, and small numbers of 9 other species. Counts of house flies on the anaplasmosis test animals varied from 3 to 13.6 at various observations and the peak occurred from June 14 to 21. Stable fly populations varied from 12 to 14, with the peak occurring from June 14 to 28. Horn fly population was never numerous, ranging from 42 to 94 with the peak occurring from June 1 to 10. As in 1964, all evidence suggests the horse flies are the primary vector of anaplasmosis and that mosquitoes apparently are not involved.

At Beltsville, Maryland, studies on the transmission of bovine anaplasmosis were continued, but at a much reduced level because of other research on disease transmission. Transmission trials and attempts to develop "infected colonies" of ticks have been unsuccessful. Colonies of ticks are being established from infected areas.

2. Equine Piroplasmiasis. At Beltsville, Maryland efforts were continued during the last year to develop an "infected colony" of Dermacentor nitens. Two attempts to infect normal colony D. nitens with Babesia caballi by allowing the ticks to feed on horses infected by blood passage were apparent failures as the resulting progeny did not transmit the disease to susceptible horses.

Two positive transmissions of Babesia caballi were obtained with the progeny of field collected ticks from two different premises in Dade County, Florida. In the first transmission trial, a splenectomized horse developed acute EP 15 days after tick exposure and died 9 days later. At the time of death none of the ticks were sufficiently engorged to produce eggs so these ticks, 79 females and 87 males, were transferred to the ears of another B. caballi infected horse. Only 4 engorged females were recovered, and the resulting progeny were lost due to incubator failure. In the second transmission trial, another horse developed acute EP 18 days after tick exposure. This horse survived the acute course of the disease. Thirty-nine engorged females were recovered, 10 of which were utilized for cytological study and the remainder were held for colonization.

A third positive transmission was obtained by exposure of an uninfected horse to approximately 1,000 progeny of ticks fed on an EP infected horse. The horse developed acute EP 18 days after tick exposure and survived the acute course of the disease. Ten engorged females were recovered. Three were used for cytological study and the remaining ticks were held for

colonization. Providing this colony can be maintained and strengthened, a Babesia caballi infected colony of D. nitens will be established. Two positive serial transmissions indicate that the parasite and this particular strain of D. nitens are well adapted to each other.

In one attempt to infect Dermacentor nitens with Babesia equi, a splenectomized horse was infested with approximately 20,000 larvae from the normal colony. On the 6th day after infestation the horse was inoculated with B. equi infected blood from a carrier animal. Acute B. equi infection developed 5 days later and death occurred on the 9th day after inoculation. None of the ticks had fed sufficiently for oviposition. Molting nymphs and flat adults were transferred to another horse infected with B. equi, however, none of the ticks attached.

Engorged females from test horses infected with B. equi were examined systematically to determine the development of B. caballi during the preoviposition and oviposition periods. Gut smears were made daily as ticks dropped from the infected horses and were continued at daily intervals until the tick died or until oviposition was completed. Immediately upon death, each specimen was dissected and gut, malpighian tubule, ovary, and salivary gland tissues were subjected to routine cytological investigation. Giemsa's stain was used for all observations. Developing stages of B. caballi were first found 24 hours after the ticks dropped from the infected host. Development appears to continue for 5 to 7 days when the parasites become evident in the ovaries and in ova which are apparently mature. These preliminary studies have not completely elucidated the life cycle of B. caballi in D. nitens. However it appears that at least two stages of multiple division occur within the tick; the first occurring in the epithelial cells of the gut wall, and the second occurring in the cells of the malpighian tubules and/or in ovarian cells.

3. Bluetongue (Sheep and Cattle). Studies have been continued on the biology of insect vectors of bluetongue disease of sheep and the role of insects in the transmission of the disease. This research is conducted in cooperation with the Animal Disease and Parasite Research Division at Denver, Colorado. Research has shown that bluetongue virus multiplies in Culicoides variipennis, a proven vector of the disease. Research has also demonstrated that cattle can be involved in the transmission cycle since C. variipennis that have fed on infected cattle (infection caused artificially by inoculation or naturally by insect bite) transmitted the disease to sheep. Using an electron-microscope, studies have been undertaken to study the biology of bluetongue disease in the salivary glands of C. variipennis. When fed on Blucine (egg-attenuated), vaccinated sheep picked up enough virus to allow multiplication of this virus in the insect host so that the insects transmitted a more virulent form of the disease than was evident in the vaccinated animal.

Preliminary studies have developed a technique for feeding Culicoides variipennis through a membrane on fluids containing a known amount of

virus and shown that flies can become infected with this technique.

Biological studies of field and laboratory populations of Culicoides have been continued. An overwintering larval population at Hudson, Colorado, was studied. It consisted of Culicoides variipennis, C. crepuscularis and a new species. This larval population completed its emergence by June and by this time a continuous summer population had begun.

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LIVESTOCK ENGINEERING
Agricultural Engineering Research Division, ARS

Problem: Modern production trends are demanding more basic knowledge about the effects of environment on the health, growth, production and fertility of livestock; about structures and related equipment for maintaining desirable environments; and about methods, structures and equipment for more efficient handling and feeding. The continuing threat of nuclear warfare demands consideration of types of buildings that will provide protection from fallout for livestock and their feeds, and provide facilities for operation during periods of emergency.

Closely associated with the environment are flies and other insects. To minimize the use of chemicals for insect control there is need for developing electrical or physical means of controlling insects that affect livestock production. How to adapt existing buildings and other facilities for more efficient production, as herds and flocks are increased in size, or as farms are consolidated, is a major problem area. The flow of materials pertaining to livestock production such as feed, bedding, and wastes with the use of automated and power equipment make the farmstead arrangement an important factor affecting the efficiency of operation. Adaptations and improvements are needed to keep design of such equipment as feed bunks, self-feeding silos, and feeding floors abreast of current production practices. Improved methods of detection and control of Salmonella are needed.

Automatic running-water systems, more water-using equipment, new uses for water, higher standards of sanitation, and other factors are continually increasing the demand for water on the farmstead -- both in quantity and quality.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving agricultural engineers, architects, electrical engineers, and physicists engaged in basic and applied research in cooperation with representatives of other research disciplines. Much of the work is conducted cooperatively with State Agricultural Experiment Stations and industry. The program is conducted and reported under the following categories: (The Federal research effort in terms of scientific man-years is shown in parenthesis at the end of each statement. An asterisk (*) is placed where the effort shown is for the entire research program in that area including livestock and poultry.)

A. Dairy Cattle Engineering. Dairy cattle environmental and bioengineering studies are conducted in a climatic laboratory at Columbia, Missouri, in cooperation with the Dairy Husbandry and Agricultural Engineering Departments of the Missouri Station. AH, ARS, serves in an advisory capacity. The influences of building arrangement, equipment, and chore routines on the amount and drudgery of dairy chores and means of improving these factors are studied in cooperation with the California Agricultural Experiment Station. Typical plans for dairy structures are developed at Beltsville, Maryland. (3.8 SMY)

B. Beef Cattle Engineering. Beef cattle structures and equipment research for hot, dry climates is conducted in cooperation with the California Agricultural Experiment Station at the Imperial Valley Field Station, El Centro. Typical plans for beef structures are developed at Beltsville, Maryland. (0.7 SMY)

C. Swine Engineering. Swine structures and equipment research for hot, dry climates is in cooperation with the California Agricultural Experiment Station at Davis and for hot, humid regions at Tifton, Georgia, in cooperation with the Georgia Coastal Plain Experiment Station and AH, ARS, on an "occasional visit" basis. Typical plans for swine structures are developed at Beltsville, Maryland. (1.8 SMY)

D. Poultry Engineering. Poultry house environmental design criteria are investigated in controlled-temperature laboratory studies at Beltsville, Maryland, in cooperation with AH, ARS, and the basic laboratory data are applied to experimental poultry houses of the NE-8 Regional Project for evaluation.

Limited field studies on relation of housing structures to poultry disease are conducted in Mississippi in cooperation with the State Agricultural Experiment Station and AH, ARS. Environmental influences on health and housing requirements are investigated in new laboratories at Athens, Georgia, and State College, Mississippi, in cooperation with AH and ADP, ARS, and the respective State Agricultural Experiment Stations. At St. Paul, Minnesota, a study of the role of environment in the prevention and control of chronic respiratory disease in turkeys is underway in cooperation with the Minnesota Agricultural Experiment Station. Typical plans for poultry structures are developed at Beltsville, Maryland. (3.4 SMY)

E. Livestock Shades and Shelters. Shades for sheltering livestock are being studied at Davis, California and Tifton, Georgia, in cooperation with the respective State Agricultural Experiment Stations. (0.0 SMY)

F. Sky Radiosity Studies. Studies of sky radiosity (total radiation) are conducted at Davis and elsewhere in California, and at Columbia, Missouri, in cooperation with the respective Agricultural Experiment Stations. (0.4 SMY)

G. Reducing Pesticide Residues in Animal Products. Reduction of pesticide residues in animal products, with beef cattle receiving major attention, is studied at Kerrville, Texas, in cooperation with ENT and ADP, ARS, and the Texas Agricultural Experiment Station. (0.5 SMY)

H. Water Supply and Wastes Disposal for the farmstead are studied at Beltsville, Maryland; College Park, Maryland, in cooperation with the Maryland Agricultural Experiment Station, and Watkinsville, Georgia. Liaison is maintained with SWC (ARS) the Public Health Service, the Water Systems Council, the American Society of Agricultural Engineers, and other organizations concerned with rural sanitation. (2.0* SMY)

I. Farmstead Planning studies are made at Beltsville, Maryland, at St. Paul, Minnesota, in cooperation with the Minnesota Agricultural Experiment Station, and at Davis, California, in cooperation with the California Agricultural Experiment Station. (1.0* SMY)

J. Fly Control in dairy operations is studied at Beltsville, Md. (1.0 SMY)

K. Sonic and Ultrasonic Energy for Control of Flies was studied at Blacksburg, Virginia. (1.0 SMY*)

L. Effects of Electric Glow-discharge Radiation on Salmonella were studied at Pullman, Washington. (0.1 SMY)

M. Equipment for Livestock and Poultry Feeding is under development at the Washington and Illinois State Experiment Stations. Work on performance characteristics of upright-silo unloaders and special duty motors is in cooperation with the Minnesota State Experiment Station. (1.8 SMY)

N. Electric and Solar Equipment for Environmental Control. Research on equipment for basic and applied studies involving light and thermal environment for poultry is underway at Beltsville in cooperation with the Poultry Branch, Animal Husbandry Research Division. Basic and applied studies on the use of heat pumps to modify thermal environment for hog production is conducted at Holland, Virginia, in cooperation with the Virginia Agricultural Experiment Station.

The influence of electric equipment and environment on health and disease is being studied in USDA laboratories at Athens, Georgia. Studies on the performance of milk handling equipment are underway at Beltsville in cooperation with the Animal Husbandry Research Division and the Eastern Utilization Laboratory. (1.8 SMY)

O. Research Instrumentation. At Beltsville, a program is underway to develop and provide accurate, practical and sometimes complex instrumentation for specific program needs. (1.0* SMY)

PROGRAM OF STATE EXPERIMENT STATIONS

There is an extensive program of both basic and applied research underway at the State Agricultural Experiment Stations in an effort to provide the answers to the continuing series of questions being raised by livestock producers. Demands are being made for more information on the effects of environment on the physical well-being of all classes of livestock, and the way such optimum environments can be economically achieved; on new approaches to meet the growing labor shortage; on methods to adapt existing structures and equipment for greater economy of production; and on structures and related equipment for improved efficiency of feeding and materials handling operations.

Studies are being made on the effect of environment on the health, growth, production and fertility of dairy cattle, beef cattle, poultry and swine. Equipment and systems for efficiently transporting feedstuff into and out of storages and automatically mixing and feeding complete rations are being developed.

Exploring methods for improved care and housing of farm animals with greater economy and labor efficiency are also in progress as well as investigation of ways to modify existing structures and equipment to meet present-day economic conditions.

Much of the work is cooperative with the Department.

A total of 27.0 scientific man-years effort is devoted to this work.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Dairy cattle engineering

1. Increasing efficiency of operations. At Davis, California, studies to determine the effectiveness of herringbone milking parlors in reducing the labor requirement in large-scale dairy enterprises were continued in cooperation with the State Agricultural Experiment Station. Time and travel studies have been made on milking operations in a total of 64 herringbone layouts, 10 of them during the reporting year. Findings during the year confirm those indicated previously which are: (1) herringbone milking parlors are just as satisfactory for milking large herds (1000 cows or more) as for small; (2) herds can be milked faster (on a man-minutes per cow basis) in a herringbone parlor, with the same effort, than in any other type of milking layout -- assuming proper arrangement, good routine, and good equipment in proper adjustment; (3) herringbone layouts cost no more, and in some cases less, (on a per milking stall basis) than other types of elevated stall layouts; (4) herringbone layouts have little or no advantage over other types of elevated stall layouts for herds of less than about 35 cows; and (5) some

operators place the milking machine on the cow between her hind legs, instead of from either the right or left flank, and believe this suspends the machine from the udder at a more natural angle. Results are being prepared for publication.

Preparation of a manuscript on facility layouts covering several years' study has been completed. Some of the principles covered have already been used as the basis for technical papers and other publications.

2. Bio-engineering studies. Basic fundamental studies on the relationships between environment and various dairy animal health and production factors were continued in the psychroenergetic laboratory, and related facilities, at Columbia, Missouri, in cooperation with the Missouri Station.

Studies of inspired-air modification for lactating Holstein dairy cows were continued during the year. The current study is to determine the effects of reducing total heat content of the inspired-air by dehumidification as opposed to the temperature reduction method previously reported. Subjecting the cows to a room environment of 85°F and a high humidity (90 to 95 percent R.H) while supplying low humidity air (25 to 35 percent R.H) at the same temperature for breathing purposes resulted in marked reactions in milk production, feed consumption, rectal temperature and respiration rate. When the inspired-air humidity was increased to the high level while the room humidity was held low, the reactions for all except respiration rate were affected to a lesser extent; respiration rate increased. All the results indicate high humidity room environment to have a more detrimental effect on heat dissipation than high humidity inspired-air. This study substantiates the previous inspired-air cooling investigation, as results of both studies have shown it is possible to markedly alter the heat dissipation by lactating Holstein cows by changing the total heat content of the inspired-air. Neither method of altering total heat content (by cooling or dehumidification) of the inspired-air will produce the benefits of cooling or dehumidifying the total environment, however.

Preliminary investigation of continuous flow metabolism measurements for lactating Holstein cows indicated such a system to accurately reflect the effects of environment and other factors on the metabolism of large animals.

The study comparing an air-conditioned dairy barn with a dry-lot confinement system was continued during the summer of 1965. Two groups of 16 cows were used in the switchback design (3-week treatment periods, with three reversals). Results of this second test season agreed with the first season's results: highly significant (1 percent level) differences occurred in rectal temperature and milk production, with the air-conditioned barn providing the more favorable environment in both cases.

Analysis of dairy cow activities under the controlled-environment and dry-lot confinement systems for the 2 years indicated only small differences in the total amount of time spent at specific activities for the two systems. However, the diurnal distribution of the activities was quite different.

Heat sensitivity studies on mature dairy cows continued during the summer of 1965. Observations made on lactating Holsteins held in a 43°C (107.6°F) environment until a 1°C (1.8°F) rise in body temperature had occurred showed significant correlation between cows (99% confidence level) and between rate of milk production decline and rate of rectal temperature rise (95% confidence level), and no trend of rectal temperature use with season.

3. Plan development. At Beltsville, Maryland, in cooperation with the Northeastern Regional Plan Exchange sub-committee on dairy housing, the following plans were developed:

Plan No. 5977, "Dairy Housing Equipment, Permanent Type." This plan was originally developed by Massachusetts.

Plan No. 5985, "101 Cow Free-stall System," originally developed by Connecticut.

Plan No. 5987, "Liquid Manure Tank."

Plan No. 5981, "Rectangular Concrete Manure Tank." (Also in cooperation with the Portland Cement Association).

Plan No. 5984, "Circular Concrete Manure Tank." (Also in cooperation with Portland Cement Association)

B Beef cattle engineering

1. Hot, arid climates. These investigations are conducted at Davis, California, and at the Imperial Valley Field Station (El Centro) of the University of California, in cooperation with the Departments of Animal Husbandry and Agricultural Engineering of the California Agricultural Experiment Station.

The 35x75 ft. laboratory at the Imperial Valley Field Station was completed early in 1966. It consists of three working rooms (animal operating room, machine and control room, and feed storage room) and an animal laboratory 25x75 ft. The latter room is fitted with 12 individual, removal pens 4-1/2x 12 ft. There are three separate concrete manure pits 18x21 ft. under the pens; the pits are covered with concrete slats. A 15-ton refrigerating unit has been installed which, at present, has only simple air temperature thermostats controlling the compressors. During the summer of 1966, the operation of the laboratory will be checked out with a single comparison of beef cattle gains and feed utilization in a 75 to 80°F temperature to those of beef cattle raised in the normal out-of-doors summer environment.

Effect of shade height on physiological responses of beef cattle was studied at Davis and El Centro. Three 8x12 shades 6, 9, or 12 ft. high and so spaced that their shadows would not overlap were constructed at Davis and El Centro. Four halter-broken steers were used in a latin square design with one animal kept at the center of the shadow of each shade (and one in the sun) during each of four days at Davis.

Respiration rate, pulse rate, surface temperature (thermocouple) and rectal temperature (rectal thermometer) measurements were made, one for each animal, once each hour from 10 a.m. to 5 p.m., on July 28, 29, and August 2, 3 1965. The animals were then moved to El Centro and after two weeks acclimation, they were put through a test identical with the one at Davis. The El Centro Tests were conducted on August 16, 17, 18, and 19. Ping-pong black-globe thermometers were kept at the centers of the shadows of the shades, and one was always in the sun. Other hourly measurements included wind velocity, relative humidity, air temperature, and horizontal surface radiation (Eppley normal-incidence radiometer). The radiant heat load was lowest under the high shade and highest under the low shade (clear sky, low humidity). Shade significantly ($P = .01$) reduced rectal temperatures, respiration rates, and surface temperatures of the steers; also, all were generally higher under the low shade and lowest under the high shade.

Study of sloping floors for beef cattle feedlots, started in 1963 at El Centro to investigate the manure removal problem in beef cattle feedlots, was continued. During the summer of 1965 four sloping floors were used (concrete floors 12x14 ft. with a slope of 4.75 degrees, or

about 1 inch per ft.). Pits 6 ft. wide were built on the lower end of two of the floors and covered with concrete slats. On one pen the feed bunk was at the lower end so the animals stood on the slats to eat; on the other three it was at the upper end. A water flushing system was installed at the upper end of one of the two floors that did not have the pits. There were six steers on each floor with an area of about 40 sq. ft. per animal. Six animals in a fifth pen (dirt) had about 120 sq. ft. per animal. The test started on June 7 with steers averaging 751 lbs., and was concluded August 11 when the steers averaged about 983 lbs. Manure accumulation on the lower part of the sloping floors was less than in the previous year; considerable manure still accumulated at the upper end. Flushing prevented this accumulation, and a flushing system combined with sloping-slotted floors might be feasible. Activity studies showed that steers seldom stood or lay on the slotted floor. The gains and efficiency on all floors, except the sloping floor without slats or flushing, were very good, but the differences were not statistically significant. Animals continued to be rather dirty, but this fact did not seem to affect gains or carcass grade. The slotted pit performed satisfactorily and was remarkably free of odor and fly larvae.

Cooled drinking water for cattle was investigated at El Centro. Past tests within this project showed there was an advantage, in terms of animal weight gains and feed conversion rates, for beef cattle drinking 70°F water rather than the 90°F water usually available at the pens in El Centro during July, August, and September. Tests were initiated during the summer of 1965 with various water temperatures for the purpose of defining more closely the best temperature of drinking water (or the amount of cooling required). A total of 8 pens was used (15x45 ft. with 15x16 ft. shade) with 4 treatments. Two pens each of six steers constituted one treatment. The treatments were 60, 70, 80, and 90°F drinking water temperatures. A 3-ton central water chiller was used for a supply of cold water that was circulated through a copper-coil exchanger in each water tub. The waterers were concrete tubs, 30 inches deep and 36 inches in diameter. They were covered except for a small opening through which the animals could drink. The test ran from June 30 to October 6, 1965. As of the reporting date the detailed data on animal sizes, etc., were not available at Davis. The overall results, however, are summarized below.

Water temperature °F	90	80	70	60
Av. daily gain lb.	3.41	3.30	3.24	3.28

Cooled water showed no effect on weight gains, but there were some complicating factors in the equipment used for chilling the water. This test will be repeated in the summer of 1966.

Beef cattle shades were studied at Davis to establish the requirement for shade for beef cattle there. The experiment began June 15 and ended October 12, 1965. The treatments were shade and no shade, with three replications. The animals were randomly assigned to seven groups of 10 each and then to six identical, completely concrete surfaced pens. The seventh group was slaughtered immediately to establish initial body composition. All cattle were slaughtered at the end of the trial. Carcass specific gravity was the essential parameter used to calculate energy retention during the feeding period. Each pen provided 320 sq. ft. (40x80 ft.) of space per animal and the 12x24 ft. shade in the center of each shaded pen provided about 29 sq. ft. of shade per animal. Approximately 510 hours of air temperatures were over 29.5°C (85°F) during the summer. This is 100 hours less than the five year (1961-1965) average of 613 (Davis, California) and 280 hours less than the highest value recorded during the period averaged. Shade had no beneficial effect on any of the measured criteria for response.

Winter stalls for beef cattle were investigated at Davis. The six shade units (12x12x10 ft high) used during the summer were modified with adjustable legs (8 and 10 ft. height) and removal stalls (six stalls per 12x12 ft. shade unit). Three of the six concrete pens

(40x80 ft) were each provided with two shade units (12x12x8 ft. high) and each shade unit having six stalls (40"x5'-6"). The other three pens were not provided with shelter or stalls. Nine animals were assigned at random to each of the six pens on November 2, 1965 (initial wt. 476 lbs. av.), and the study terminated on March 22, 1966 (final wt. 895 lbs. av). The average daily gain and feed conversion is as follows:

<u>Stalls</u>					
Date	11-30	12-28	1-25	2-22	3-22
ADG	2.83	3.25	3.12	3.07	2.98
F/lb. G.	5.46	5.39	5.81	5.99	6.24
<u>No Stalls</u>					
ADG	3.16	3.50	3.16	3.07	2.99
F/lb. G.	5.19	5.22	5.89	6.15	6.37

There was no difference in the rate of gain or feed conversion of the animals in the above treatments, but the animals in stalls were much cleaner.

2. Hot, humid climates Inactive during reporting period.

3. Plan development. At Beltsville, Maryland, in cooperation with the Southern Regional Plan Exchange, Plan Number 5991, Beef Cattle Corral, 50 head was approved and issued for national distribution.

C. Swine Engineering. Swine environmental studies were conducted at Davis, California, in cooperation with the Animal Husbandry and Agricultural Engineering Departments of the California Agricultural Experiment Station. These include studies on humidity effects and swine moisture loss measurements in a controlled laboratory, and field tests on swine exercise and ultraviolet lights. Tests were continued at Tifton, Georgia, in cooperation with the Georgia Experiment Station. This was the final year for tests relating the use of sprinklers under shades to reproduction of sows and gilts and growth of market hogs.

1. Effect of humidity on swine . Study of influence of humidity on growth rate and feed utilization of swine was continued in a controlled laboratory at Davis. Two additional humidity tests were completed in the chamber during the year. These are Tests IV and V, summarized below. To briefly review, three separate rooms were installed in the psychrometric chamber. The dry bulb temperature and dew point of each room can be individually controlled. Three Durocs are put into each at the beginning of the test, and they usually weigh about 80 lbs. The humidity was either 45, 70, or 95% in all except Test IV when the humidities were maintained at the optimum prescribed from results of previous tests on this project. In Test IV, the dry bulb temperature was 10°F above the optimum. The pigs had a floor area of about 8 sq. ft. per pig and the air flow rate (3 changes/minute) was about 10 ft. per minute. The results for this year's tests (Test IV and V), as well as for past tests, are summarized below.

Test	Dates	D.B Temp.	Humidity 1/		
			Low	Medium	High
			Av. daily gain, lb.		
II	12/17/63-3/25/64	Opt.	1.56	1.48	1.41
III	12/10/64-3/18/65	Opt.	1.57	1.42	1.56
IV	6/16/65-9/14/65	10° above Opt.	1.33	1.30	1.12
V	12/19/65-3/23/66	Opt.	1.59	1.54	1.45
				Lb. feed/lb. gain	
II	-	Opt.	3.71	3.67	4.16
III	-	Opt.	3.49	3.67	3.06
IV	-	10° above Opt.	3.52	3.56	3.65
V	-	Opt.	3.56	3.48	3.70

1/ Low, medium and high humidities for Test IV were 30, 60, and 90%; for all other tests, 45, 70, and 95%.

There has been little apparent effect of humidity when the dry bulb temperature was near optimum except that the differences in daily gain approached significance ($P = 0.05$) in Test V. With the higher dry bulb temperature IV the humidity effects, or at least the effects of the 90% relative humidity, were stronger. Additional tests at higher than-optimum temperatures are needed and are planned for the coming year. Surface and rectal temperatures have been measured regularly.

2. Sprinkling for hot, humid climates. Study of the influence of sprinkling pigs and sows in a hot climate was continued at Tifton, Georgia. Sows and gilts; Four one-acre, temporary pasture lots were

used, each with two shade units. In two of the lots, each shade unit had two fog nozzles (Monarch #4.6160, 2.3 gal/hr at 25 psi) mounted 8 ft. apart and 3 1/2 ft. above the ground, directed down. The sprinklers were on from 8 a.m. to 7 p.m. Eight bred animals in each lot were started on test May 4, 1965, and were moved into the farrowing barn on July 28. Two of the four lots (one with gilts and one with sows) had shade and sprinklers. The other two lots (one with gilts and one with sows) had shade only. Fog nozzles located under the shade during the summer gestation period did not affect reproduction performance of gilts and sows. This was the fourth year of this study and it will be terminated. Pigs: In 1965 the environment under movable shades was modified by use of an electric fan blowing air lengthwise under the shade on the pigs. The fans were 36" in diameter (11,000 cfm). The test was started May 11 with 10 Duroc pigs per lot averaging 48.4 lbs. each. Two lots had shade (12x16 ft.) and one fan each and two lots had shade only. After 87 days (pig weight 200 lb) there were no significant differences in daily gain or feed consumption between the two treatments.

3. Swine exercise. Swine exercise experiments have been conducted for several years in an effort to evaluate possible means of increasing certain of the more expensive muscle cuts of pork, such as the hams and loins. Two phases of this work were conducted during the reporting year.

a. Treadmill: A treadmill was constructed so that 4 or 5 pigs could eat at stand-up feeders while their back legs were on the treadmill. The pigs had to walk on their hind legs while eating. For the first trial, February to April 1965, the comparison group used with the treadmill group ate at an elevated feeder like the one the treadmill group ate from. The pigs were fed twice a day so the treadmill was on for two periods a day, for about one hour each time. For the second trial July 14 to September 13, 1965, the pigs were restricted to 8 sq ft per animal and were fed individually twice per day. The pigs were removed from the test when they were 200 lbs. A control group was group-fed in a trough at ground level. A second control group was similar to the test group (standing to eat) but did not use a treadmill. No measurable effects were observed in either test. Muscle samples were taken from all slaughtered pigs and analyzed by Veterinary Medicine. Results of these analyses are not yet available.

b. Walking: This study was made to observe the effect of exercise on rate of gain and eating habits of swine. It was started on January 17, 1966, and ended on February 14. Two pens in the hog barn were used. One pen had 8 pigs which were exercised twice daily about 9 a.m. and 4 p.m. by running and/or walking twice to the end of the outside alley (about 10 minutes per two trips). Eight pigs in the other pen were not exercised except for weighing. After two weeks, the lowest pigs in the exercised group and two pigs in the other (lowest weight) were removed from the test. The four-week gains are shown below:

Pen	ADG - lbs		Feed/gain	
	2 weeks 8 pigs	4 weeks 6 pigs	2 weeks 8 pigs	4 weeks-6 pigs 2 weeks-2 pigs
Exercise	0.90	1.37	5.90	4.34
No exercise	1.59	1.62	4.25	4.18

Pigs were marked on the backs so that the position of each pig in the pen was known. The activity cameras (single frame movie at 10 minute interval were mounted overhead of each pen and ten 24-hour periods were analyzed (January 19, 20, 24, 25, 26, and February 1, 7, 10, 11, and 14). It was assumed that the pig was in the position indicated on the film for 10 minutes in the data given in the table below. (Only pigs remaining to the end of the test were included.)

The influence of exercise is evident in the table above which shows that the exercised pigs gained at a slower rate. The table below shows that the exercised pigs spent more time lying down and less time eating.

Activity of pigs with and without exercise
(walking), Davis, California

Pig No.	Total gain lb.	Exercise Pen			
		Percent of time			
		lying	eating	standing (incl. eat)	stand, no eating (by subtraction)
145	16	93.0	6.5	7.0	9.5 Difficult to walk
59	38	87.6	9.0	12.4	3.4 Difficult to walk
74	70	86.8	9.4	13.2	3.8
151	46	86.1	8.8	13.9	5.1
16	36	85.1	11.7	14.9	3.2
162	54	82.6	11.5	17.4	5.9 Moved out freely
Mean	38.3	86.87	9.48		

Pig No.	Total gain lb.	No Exercise Pen			
		Percent of time			
		lying	eating	standing (incl. eat)	stand, no eating (by subtraction)
48	36	88.6	6.9	11.4	4.2
73	50	85.9	8.8	14.1	5.3
18	48	83.6	11.7	16.4	4.7
89	52	82.8	11.2	17.2	6.0
152	44	81.3	11.7	18.7	7.0
130	42	78.5	13.5	21.5	8.0
Mean	46.3	83.45	10.63		

The difference in mean time lying is almost significant. For the exercised pen the correlation coefficient between gain and standing time is 0.98. No correlation for the other pen.

4. Moisture loss. Study of skin and lung moisture loss from swine was continued at Davis. Tests were made to determine, as accurately as possible for swine, (1) the moisture loss at a moderate and at a high temperature at constant dew point; (2) the effect of dew point or vapor pressure on moisture loss at a relatively high temperature; and (3) the relative importance of the respiratory system and skin as sources of water loss. A pig was trained to be in a cage of expanded metal within a rigid plexiglass enclosure through which air was blown: Lithium-chloride-type dew point measuring devices were used in the inlet and exit air streams. Air velocity past the pig in all tests was about 5 fpm, but the volume was such that there was a rise of only about a degree in dew point as air passed through the enclosure.

The entire apparatus and also housing for the pigs were located in a controlled environment chamber. During the first half of a run, total moisture loss was measured; a mask over the pig's snout served only to catch saliva. A small blower within the enclosure supplied fresh air for breathing by means of a flexible tub attached to the mask. For the second half of the run, flexible tubes were connected to the mask so that air was brought from, and exhausted to, the outside of the enclosure, thus enabling skin moisture loss to be measured.

The table below shows a summary of data from the last tests (2 Duroc gilts, 198 lb).

TEMP. °F		RH%	Moisture Loss, Grams/Min/Pig		
DB	DP		LUNGS	SKIN	TOTAL
60	50	70	0.28	0.38	0.66
85	50	30	0.87	0.72	1.59
85	64	50	1.12	0.59	1.71
85	74	70	0.78	0.86	1.64
85	82	90	0.41	0.83	1.24

Skin moisture loss ranged from 35 to 67 percent of the total amount vaporized. With a change in air temperature from 60 to 85°F, at constant 50°F dew point, the pigs were able to offset the decrease in sensible heat loss by doubling the skin loss and tripling the lung loss, the latter by means of tripling the volume rate of respiration. At constant 85°F air temperature with dew point increasing from 50 to 82°F (30% to 90% RH) skin loss remained nearly constant and lung loss actually increased then decreased. Skin loss, usually about half the total loss increased to two-thirds at 85°F DB - 82°F DP

5. Ultra-violet radiation. Effect of ultra-violet radiation on swine

was studied at Davis. Three tests have been completed to measure the effect of ultra-violet radiation on weight gain and feed utilization. Two tests were conducted at the hog barn and a third was conducted at the Stralock Farm. At the hog barn, one Sterilamp (30 watts, 2537 Angstroms) was hung about 10 feet above the center of each of six 10x13 ft. pens holding 5 pigs each (5 treated pens in Trial 1 and 6 treated pens in Trial 2). The pigs were on concrete floors, had automatic waterers and self-feeders. The number of check pens was equal to the number of treated pens in each case. The lamps were on all the time except when someone was cleaning the pen. In the test at Stralock, a group of 24 Duroc pigs were fed individually (twice per day) in two 9x24 ft. pens. Twelve of the pigs were exposed to six "Sterilamps" (30 watts, 2537 Angstroms) mounted 9 ft. above the floor of one of the two pens. There have been no effects of ultra-violet radiation in any of the three tests. The results are summarized in the table below.

	Ultra-violet light		Control	
	Av. Daily gain lb.	Feed/lb gain	Av. Daily gain lb.	Feed/lb. gain
Trial I				
12/14/64 to 2/10/65				
5 pigs/pen	1.42	3.15	1.42	3.26
Trial II				
6/23/65 to 8/18/65				
5 pigs/pen	1.39	3.81	1.35	3.83
Trial III				
1/3/66 to 3/14/66				
12 pigs/pen	1.70	3.76	1.65	3.80

6. Plan development. At Beltsville, Maryland, in cooperation with the Southern Regional Plan Exchange, Plan No. 5986, "Part Slat Feeding Floor for 200 Pigs," was developed and published for national distribution, and at the request of the Southern Regional Plan Exchange Committee, Plan No. 5993, "Shed Type Farrowing House or Farrow to Finish Unit," developed by North Carolina, was included in the Plan Exchange. The plan shows eight pens with removable farrowing stalls. Length of the building may be varied in units of 12 feet (two pens). Pole-type construction is specified. Also at Beltsville, but in cooperation with the Western Regional Plan Exchange Plan Number 5988, Swine Feeder, which was originally designed by Montana was modified, developed and published by the Plan Exchange for distribution nationwide.

D. Poultry Engineering

Poultry house environmental design criteria were investigated in controlled-temperature laboratory studies at Beltsville, Maryland, in cooperation with AHRD. Environmental influences on health and housing were investigated in the Southeast Poultry Research Laboratory, at Athens, Georgia, in cooperation with ADP and AH (ARS) and the Georgia Agricultural Experiment Station and in the South Central Poultry Research Laboratory at State College, Mississippi, in cooperation with AH and ADP (ARS) and the Mississippi Agricultural Experiment Station. Criteria for design of heating, ventilation, and air conditioning equipment for turkey production were investigated at St. Paul, Minnesota in cooperation with the Minnesota Agricultural Experiment Station. At Davis, California, studies were continued to determine the influence of air ion polarity on poultry (Japanese quail.) in cooperation with the Poultry Science Department.

1. Calorimeter studies at Beltsville. Heat and moisture data from broilers, along with other biological data necessary for designing a broiler house and its ventilation system, were partially developed.

Studies of growing broilers from hatch to 35 days of age showed that brooding may be started at air conditions of 86°F and 75% RH, or at 94°F and 50% RH. Small chicks averaging near 30 grams required at least 91°F and 75% RH. After a period of brooding, the maximum live weight of broilers was obtained at air temperatures between 65° and 75°F. Surprisingly, the rate of respired moisture production in per pound live weight, for any given average weight of broilers was nearly constant for all temperature levels between 57+2 and 84+2°F. Calculations show that 1000 broilers averaging 0.5 pound will respire 55 pounds of water per day, while a similar number of 4 pound broilers will respire 130 pounds. Further calculations show that the amount of water in the fecal matter for 1000 four pound broilers at 9 weeks of age and at 41°F and 68°F amounts to 350 and 290 pounds per day respectively. Chicks averaging 0.5 pound will produce 62 pounds. Broilers averaging 0.5 pound lost 40 percent more sensible heat in per pound live weight at 57+2°F than at 84+2°F. When broilers averaged 4 pounds, there was 25 percent more heat loss at 57+2°F than at 84+2°F.

It is planned to develop the engineering application and to check these laboratory data in an experimental broiler house at the University of West Virginia.

Winter studies of turkeys showed that 31-month old females averaging 11.5 pounds panted at 80°F and 65% RH, while 7-month old males averaging 22.5 pounds panted at 73°F and 63% RH. These temperatures appear to be lower than those at which they pant in the summer. In per pound live weight units, the 22.5 pound males respired slightly less than did the 4 pound broilers at temperature between 55 and 73°F. At 80°F these turkeys respired moisture at about the same rate as the broilers. Similar data showed that the 11.5 pound non-laying female turkeys respired at about 1/2 the rate of 4-pound broilers at temperatures between 55 and 73°F, and at 80°F slightly less than the broilers.

The rate of sensible heat production in per pound live weight units, was 1/2 to 2/3 of that for broilers averaging 4 pounds. The fecal production rate of the hens averaged 0.5 pound per day at all temperatures studied, while the males differed -- 0.73 pound at 55°F, 0.48 pound at 73°F and 0.67 pound at 81°F. For both sexes the fecal moisture content was close to 80 percent. Four additional tests should be conducted in the summer to obtain data reflecting seasonal change on adult male and female turkeys.

No studies on laying hens were conducted during the reporting year. Plans are underway to equip the five environmental chambers to study bird density and high and low energy diets in wire laying cages.

2. Southeast Poultry Research Laboratory. Engineering activity at this recently completed facility is largely still concerned with development, procurement, and installation of test equipment and instrumentation for the engineering portions of contemplated multi-discipline research programs.

During the report year, two additional prototype environmental cabinets, with control panels, were completed and performance-tested. Currently four cabinets with control panels have been completed, together with planning and installation of hot and cold liquid supply systems. The four cabinets are of similar construction, although not identical in all details. Provision has been made for programming temperature of air (both dry bulb and dew point), of each sidewall separately, of the top surfaces, and of the bottom. In addition, air circulation may be regulated within each cabinet, and the quantity of air exhausted can be regulated and adjusted. Automatic feeders with convenient height adjustment have been installed, and automatic waterers with height adjustment, overflow, and flush cleanout have been constructed and installed. In addition, a rotary table for work surface was installed in each cabinet. Two refrigeration units have been installed to provide cold liquid to six cabinets. (Two more cabinets are contemplated to complete installation of this unit.) Two gas-fired water heaters have been installed for hot liquid supply. The four environmental cabinets with all necessary components had been in operation for about two weeks (as of the reporting date)-both with and without chickens-and so far appear to be functioning adequately.

In addition to the four cabinets in operation, work was completed on another prototype cabinet of somewhat different design. Both cabinet and control panel differ appreciably from those now in use. Cabinet construction is considerably simplified, several controls eliminated, and both labor and time requirements reduced considerably.

3. South Central Poultry Research Laboratory Engineering research to determine by experimental procedures the effects of construction, equipment and management of poultry housing structures on broiler diseases and condemnations has been initiated at this newly constructed facility in cooperation with AH and the Mississippi Station. Initial work is being conducted in four research poultry houses on the laboratory farm and is concerned principally with the influences of insulation and brooding equipment on selected environmental factors associated with the economics of poultry production. Early studies show:

Broiler houses with insulation installed and with our management practices have given some advantages over the noninsulated broiler houses in average weight, feed efficiency, mortality, and brooding cost, but gave a disadvantage in condemnation loss.

Using part of the broiler house as a starting pen or brooding area for the baby chicks appears to be desirable, with brooding costs reduced from the present system of using the entire house for brooding as well as growing.

It is desirable to have an air space between metal roofing and insulation and this air space vented at eave and ridge so as to reduce metal surface temperature as well as heat intake into the house during high temperature periods. Using the roof surface to condense excess moisture out of air during low temperature periods appears to be feasible and practical to reduce heat loss to the building.

A constant low (40°F) room temperature does not appear to increase broiler condemnation as much as a diurnal fluctuation from 40°F to 80°F.

4. Field observations on relation of housing to disease in broilers in the South Central States. Work in Mississippi, in cooperation with AH and the Mississippi Station has continued at a reduced pace. Two comparable houses on a commercial broiler producer's farm, both having insulation in the roof and winch-adjusted woven plastic curtains on the sidewalls, were studied to compare fan versus natural ventilation. Fans were controlled by thermostats and time switches - natural ventilation was manually controlled. Data are not yet available.

5. Influence of turkey housing environment on disease. The relation of turkey disease and environment is studied at St Paul, Minnesota. The last seven experiments in the Environmental Turkey Building have been on the effectiveness of Tylan dipped turkey eggs in eliminating the transmission of N strain PPLO through the egg. The first flock resulted in disease-free birds at market age. The present flock (No. 7 in this building) is also disease free

During these studies a data acquisition system has been under development. Temperatures, and wind direction and velocity are now being recorded. As sensors for other data are obtained, or devised, an environment monitoring system with computer analysis of data will be completed.

Diseases other than those under study have gained entry into the facilities. Blackhead did not develop in pens with concrete floors. With one type of E-coli an infra-red lamp brooder possibly facilitated early eating of medicated feed which resulted in low mortalities compared to commercial brooders. Studies indicate the need for structural and equipment improvements.

6. Ion polarity effects. The effects of ion polarity on poultry are under study at Davis, California. The possibility that air ions might be an environmental factor influencing growth are being investigated, using Japanese quail (*coturnix japonica*). In the studies, an environment with a preponderance of negative ions or positive ions was compared

with one of natural ion distribution as to effects on rate of growth, mortality and sexual maturity. Three enclosed brooder-housing chambers were used, each 3ft. by 4 ft. by 16 inches high. Each chamber was heated with a fan-type electric heater with a thermostat. One chamber was equipped with a negative-ion generator and a second with a positive-ion generator: Approximately 60 one-day-old Japanese quail were placed in each chamber at the start of each test. The temperature was 100°F for the first week and was lowered 10°F each succeeding week. The period of maximum growth for Japanese quail is at about 3 weeks of age, hence studies of growth were discontinued at 4 weeks.

During the first four tests, the ion generators were operated continuously; during the next two tests the birds were given a 12-hour-light and 12-hour dark schedule with ions provided only during the lighted period for the first test and only during the dark period the second test. In the last three of the 9 tests all chambers had only natural-ion conditions for the first six days, then the generators were on continuously. In tests 1 thru 4 (ions from the first day) there was a significant (5% level) weight depression when the birds were subjected to high densities of negative ions. With ions provided only during dark hours, the negative-ion group grew less than the positive-ion group but more than the "natural" group. For the first six tests combined, there was a highly significant (1% level) reduction in growth due to negative ions. When the artificial ion environment was delayed until the quail were six days old, the results were less consistent.

7. Eggshell thickness. Studies of eggshell thickness measurement by means of radioactive isotopes have been initiated at Beltsville, Maryland. This is the first report concerning this work. During the first year of the project it was found that the attenuation or absorption method of measuring shell thickness was unsatisfactory due to the great absorption of the interior of the egg. After research at both Oak Ridge National Laboratory and Beltsville and interviews by researchers from both laboratories, it was decided to use a B emitter and measure the energy bounced back to an annular Geiger-Mueller tube around the source. A thick shell will bounce back more of the particles whereas a thin one will allow more of them to go on into the egg. Since an eggshell is thicker than most of the films previously measured by this B back-scatter technique, it was decided to start with the most penetrating B source commonly used, i.e., strontium 90. This source proved not strong enough. ORNL then fabricated a more energetic B source consisting of ruthenium 106-rhodium 106. Tests conducted jointly with ORNL personnel indicated it was possible to determine the shell thickness to .001 inch using this technique; but it required ten minutes per egg. Another source has now been fabricated using more of the same isotope. This should reduce the measuring time to one minute. Further research is expected to make more reductions in measuring time.

8. Plan Development At Beltsville, Maryland, in cooperation with the Northeastern Regional Plan Exchange sub-committee on poultry, Plan No. 5978, 40' Nailed Truss for Caged Layers was placed in the Cooperative Plan Exchange for national distribution. Also at Beltsville, Maryland, in cooperation with the Southern Regional Plan Exchange Committee, Plan No. 5990, Laying House, was developed. This pole-type building is insulated and provided with both mechanical and natural ventilation. Slatted floors are used over the dropping pits under the feed and water troughs. The 40 by 96 foot building may be lengthened in units of 16 feet.

E. Livestock Shades and Shelters. Reported under B-1, p. 46; C-2, p. 49; and F below.

F. Sky Radiosity Studies Radiant fluxes from the sky, ground and surroundings are being measured at Davis and other points in California and at Columbia, Missouri, in order to evaluate the radiant environment of livestock out-of-doors.

The "short" and "long" wavelength radiation around shades of different heights was measured at Davis and El Centro, California. The two-radiometer system developed last year was used again during the summer of 1965. With this system two directional thermopile radiometers are used (Gier and Dunkle Instrument Co.) One is covered with a quartz filter so that it measures only energy of 5 microns or less. The other measures total incoming flux. The difference between the two measurements provides a measure of long-wavelength radiation (greater than 5 microns). Hourly scans were made under 8x12 ft. galvanized steel shades 6 ft. and 12 ft. high at Davis and at El Centro. Scans were made in the four cardinal directions, at 15-degree intervals from the zenith to 15 degrees below the horizon. Scans were made from 9 a.m. to 3 p.m. on July 23 and September 13 at Davis, and on August 12 and September 7 at El Centro. In addition to hourly scans with the two directional radiometers, the direct beam solar radiation normal to a surface at the ground was measured with an Eppley normal-incidence radiometer, and solar radiation on a horizontal surface was measured with an Eppley 180° pyrliometer. For the clear-sky, low-humidity conditions in which these data were obtained the following conclusions were indicated:

1. The diffuse solar energy reflected from the under side of a shade to an animal underneath is considerable, and is greater from a high shade than from a low one.
2. The percentage of short wave energy in the total radiation from shaded ground differed from that in the radiation from unshaded ground at both Davis and El Centro, as indicated in the tabulation:

% short wave energy in total radiation from:
unshaded ground shaded ground

Davis, Calif.	29	7
El Centro, Calif	23	7

3. The total radiant energy received by an animal under the center of a low shade is less than that received by an animal under the center of a high shade. When the animal is at the center of the shadow of the shade, the influence of the shade height is reversed.

4. Shades 6 feet high reduced the upper hemisphere irradiation on a horizontal surface by about 47% at Davis and by about 51% at El Centro by cutting off the direct-beam solar radiation.

A "ping-pong ball" black-globe thermometer was developed at Davis, Calif., for measuring radiant heat loads under and around shades. These black-globe thermometers were made from table tennis balls. They are only about 1-1/2 inches in diameter, compared with the 6-inch diameter copper spheres previously used. They were coated with Parson's black lacquer (emissivity 0.98) and their temperatures were monitored with 24-gauge thermocouples at their center. These globes are lightweight, small, and inexpensive.

Equations were developed for their use and their response time was studied. The globe equation is: $RHL = 0.232 \sqrt{V} (t_g - t_a) + 0.1 T_g^4$ RHL = radiant heat load, Btu/hr ft²; V = velocity of air, fpm; t_g & t_a are globe and air temperatures, respectively, deg.F. This same equation was also developed for the metric system.

When exposed to an air velocity of 400 fpm, the smaller instrument responds twice as fast (4.5 versus 9 minutes) as the 6 inch copper globe. At a low air velocity of 30 fpm the difference is less (17 versus 22 minutes). A graph was developed so the response time could be determined for any set of conditions.

G. Reducing pesticide residues in animal products.

Studies of methods and equipment for reducing the chemical hazards associated with control of livestock insects were continued at Kerrville, Texas in cooperation with ENT and ADP.

Earlier studies indicated that successful horn fly control might be obtained with 1 ml. of 10% ronnel applied to the withers of cattle. A series of tests was conducted comparing the effectiveness of a 50 ml. (0.25% ronnel) treatment from an 8-nozzle sprayer with that of a 1 ml. (10% ronnel) treatment from a 1-nozzle sprayer. In large cage tests both treatments resulted in horn fly control (1 ml. average 92.9% and 50 ml. average 98.6% mortality 24-hr. posttreatment). The first of two things

which may explain higher mortality with the 50 ml. spray is that the 50 ml. treatment contains a slightly larger amount of active material (50 ml. X 0.25% = 0.125 gms. active versus 1 ml. X 10% = 0.10 gms. active). Secondly, at one point during the tests the 1-nozzle sprayer was found to be delivering only 0.5 ml. rather than 1 ml. The results of these tests indicate that a sprayer which would consistently deliver 1 ml. of 10% ronnel to the back or side of an animal each day might afford successful horn fly protection.

Development and testing of automatic cattle sprayers was continued with emphasis on frequent low-volume applications since this procedure provides a means of reducing insecticide residues in meat and milk. Two types of low-volume automatic sprayers were used in field studies during the past year. One type employed a small electric air compressor and applied about 100 ml. of 0.1% Ciodrin from 8 nozzles. Although subjected to severe testing on a 300-cow dairy herd, this sprayer has continued to prove itself in ruggedness, dependability, and effectiveness. The second type sprayer to be field tested was an ultra-low-volume sprayer which dispensed approximately 1 ml. of insecticide (10% ronnel) from a single pneumatic atomizing nozzle. This sprayer used precompressed oxygen for pressure and a storage battery for automation. Although laboratory studies indicate that it is possible to obtain horn fly control with a 1 ml. spray of 10% ronnel, field tests and residue tests were only partially successful with this sprayer. Problems were encountered when crystallization of the spray formulation at the nozzle tip caused partial clogging. In an attempt to overcome some of the problems encountered with this 1 ml. pneumatic atomizing sprayer, a new 1 ml. sprayer was developed. This ultra-low-volume sprayer utilizes a device for measuring the quantity of insecticide to be dispensed through the single nozzle. It is self-contained and void of electricity, using pre-compressed air for pressure. Laboratory observations have shown it to be very consistent in its output, which can be varied from 1 to 5 ml. Field tests and residue tests are planned for this sprayer in 1966.

A study was begun to determine the significance of hair loss from cattle as a factor contributing to insecticide loss. Initial work has indicated that hair loss may not be significant from this standpoint. A new procedure was devised to eliminate confining the cow and thereby expose her to more natural conditions. Data collection from this method will continue through 1966.

Preliminary work with the instrumentation system for detecting and evaluating the responses of stable flies, horn flies, and face flies to various physical and chemical stimuli has indicated that it is possible to obtain a continuous flight activity record of these insects. One plan for this system is to determine the daily activity patterns of the insects and thereby determine the best time for insecticide application. Another possibility is its use for screening chemical stimuli which may later be used in application techniques. Several tests utilizing the systems are planned for 1966.

H. Water Supply and Wastes Disposal

1. Farmstead and rural water systems. Studies on farmstead and rural water supply system design criteria are continuing in Maryland, in cooperation with the Maryland Station, National Fire Protection Association, Johns Hopkins University, Federal Housing Administration, Washington Suburban Sanitary Commission and selected farmers.

2. Farm & animal wastes disposal Laboratory and field studies are continuing in Maryland in cooperation with Maryland Station. Work this year was concerned almost exclusively with the hydroponic possibilities of lagoon effluent clarification and salvage of plant nutrients in the form of an animal feed crop. In laboratory experiments plant nutrients in lagoon effluents were reduced as follows by 5-day retention in a hydroponic system with the grasses indicated:

Nutrient	% Reduction by 5-day retention*			
	Fescue	Rye	Reed Canary	Brome
Nitrate	79.5	70	64	47.5
Phosphate	63.5	66	54	60.5

*Averages of 5 repetitions

Grass yields ranged from a calculated 4.4 to 8.5 tons/acre with an ash content of from 1.9 to 3.1%. At the upper limits of tonnage and ash this is equivalent to a removal of approximately 500 lbs. of dissolved plant nutrients and trace elements on a one month, one acre basis.

Average requirements for a hydroponic system would be 2.2 acres/100,000 gal/day effluent discharge (a high rate for a farm lagoon but a good "mean" figure for small municipal sewage disposal lagoons), which gives a 5 day detention time.

Early work under regional project NC-69, Farm Animal Waste Disposal, has included collection of information on properties, handling, treatment, and disposal of animal waste. This research is cooperative among 10 North Central agricultural experiment stations and ARS, USDA. Many of the stations have investigated lagoons; others have studied use of chlorine and lime to prevent development of objectionable odors; primary or secondary treatment of swine and cattle waste in an oxidation ditch or by disposal on the land surface, properties of run-off water from open feed-lots, electro-osmosis for drying poultry manure and hydroponics as a means of clarifying and utilizing the manure lagoon effluent. The use of air oxidation devices as a means of primary or secondary waste treatment follows prior findings that anaerobic organic breakdown generally proceeds too slowly and is unreliable under most practical conditions.

I. Farmstead planning

1. Farmstead model layout studies. Studies on the use of models for analyzing farmstead layout problems neared completion in cooperation with the Minnesota Experiment Station at St. Paul, Minnesota. These studies have demonstrated that scale models can prove valuable aids in farmstead planning, analyzing materials flow problems, eliminating safety hazards, analyzing alternate arrangements, and planning for orderly expansion of the enterprise. They also showed that the scale models are only one step in the orderly process of planning the farmstead and that some system of numerical analysis is needed to supplement their use.

2. Chore time standards. Studies on time standards for performing farmstead work elements are continuing in cooperation with the Minnesota Station, at St. Paul, Minnesota.

A study of free-stall slat-floor housing for dairy cattle is being conducted in pilot units of cold and warm housing with outside feeding. The objectives are to determine the design criteria for free stalls, economical methods of manure handling, and recommendations for feed lot design. As a result of the first full winter's operation of the study it was found that the animals do not spend enough time in either type during the daylight hours, even in sub-zero weather, to keep the manure under the slats from freezing. However, the manure in the warm unit can be kept unfrozen later in the fall than the manure in the open unit, when the temperature goes below freezing at night but rises a few degrees above freezing for about four hours in the afternoon.

A study of the use of separate animal-operated self-closing entrance and exit doors in the closed unit has shown that it requires about two to four days to train all of the animals to use them properly. It was found however, that for best operation by the animals it was necessary to provide plexiglass panels in the doors such that the animals can see what is on the other side before they attempt to push the doors open.

In the study of feed-yard layout design, time lapse photography is being studied as to its suitability for recording animal movements in the yard area. Thus far it has been determined that it is necessary to use roll film of two different emulsion speeds if a record is to be obtained over the full period of dawn to dusk. Time intervals of 4 and 7 seconds appear to be the best time lapse between frames to record the animal movements.

J. Physical Methods for Fly Control

Investigations of physical methods for controlling flies in dairy operations were continued at Beltsville, Maryland, as a cooperative effort of Entomology, Animal Husbandry, and Agricultural Engineering Research Divisions, ARS, but under a handicap from shortage of personnel.

A study was initiated to evaluate the effectiveness of farmstead sanitation practices in reducing fly populations and to determine whether efforts by individual farmers are beneficial, or whether concerted community action is essential. Monitoring surveys were made of native fly populations on neighboring farmstead areas and of the dispersal of marked flies released at various points within the area.

Removal of fly-attractive materials from a dairy complex appeared to reduce the house fly population by about one-third. Stable flies were not much affected by barn and corral cleanup. House flies dispersed more rapidly from areas with few breeding sites than from areas with many breeding sites and were more attracted to farms with uncleared corrals and barns than to farms having daily manure cleanup. Most house fly dispersal occurred within 4 days after adult emergence and was quite rapid to farms within a 1-mile radius of the emergence site.

A companion study was initiated by AH through contract with Louisiana State University to evaluate effects of sanitation under the favorable conditions for flies prevailing in the South and to compare the benefits derived from different levels of effort to maintain sanitation on typical farmsteads. Cooperators have been selected and detailed observations will be made during the 1966 and 1967 seasons.

K. Sonic and Ultrasonic Energy for Insect Control

At Blacksburg, Virginia, house flies and face flies have been exposed to sounds of frequencies ranging between 100 Hz and 100 KHz at three different intensity levels. Tests included both steady and pulsating tones. Pupae of the face fly have also been exposed to sound energy at frequencies between 100 Hz and 5 KHz. Conclusive results are not yet available in these studies. Work for next year will include tests with both house flies and face flies in accordance with suitable statistical designs which are being developed for the experiments. Techniques for testing and handling flies will be refined, and studies of sonic frequencies generated by flies in flight will be initiated.

L. Effects of Electric Glow-discharge Radiation

Salmonella Studies

At Pullman, Washington, studies were continued in cooperation with the Department of Poultry Science, Washington State University, to further define the effects of glow-discharge radiation on Salmonella in dried egg powder. Experiments were designed to better define the lethal treatment for Salmonella, but repeatability of results was not satisfactory. Better control of experimental variables will apparently be required.

M. Equipment for Livestock and Poultry Feeding

1. Cattle Feeding Equipment

An extensive system has been constructed by the University of Illinois Agricultural Experiment Station (Department of Agricultural Engineering and Dairy Science cooperating) to test and develop the best complete system for optimum mechanization and/or automation of milk production equipment. The initial efforts are directed toward the development of an automatic system for dispensing one or more assembled rations to milk cows for free-choice consumption. The cows are divided into production groups so that individual cow feeding will not be necessary. The ration dispensed to each group is composed of silage (grass or corn) and a premixed concentrate. The proportion of silage and concentrate is varied according to the production level of the group. This system will permit more comprehensive investigation of system design and component functions. Considerable difficulty has been experienced during the past year with malfunctioning components of the automatic controls. More reliable components will be used. The overall purpose of this work is to improve milk production efficiency per man-hour without impairing the performance or health of the milk cow.

The automatic feeding equipment investigation for beef cattle was transferred to that for dairy cows. The requirements for each are similar and a better system was available at the dairy farm. The continuously variable, low-speed, high-torque drive for a high-moisture corn metering auger was tested and proved satisfactory. A publication describing the drive assembly is being prepared.

A pilotless-prime-mover, a new concept for automatic feed transport and distribution is being studied. At this time attention is being devoted to perfection of a guidance system that will permit direction of the powered vehicle on a path without deviation of over 2 inches from the prescribed path. The purpose of the system is to simplify mechanization of extensive cattle feedlots and to improve the means of transporting feed materials from field to storage and from storage to the point of use. A buried wire radi-

ating a low radiofrequency signal will be used to guide the vehicle. Present efforts have been devoted to taking measurements of the RF field about the buried antenna when energized at a range of frequencies to select the frequency best suited to the anticipated soil conditions.

In Minnesota, performance tests of Special Farm Duty Motors have been continued. Design engineers from four motor manufacturing companies have contacted the project leader during the past year to discuss performance requirements. Three manufacturers of silo-unloading equipment have actively sought guidelines for their purchases of motors. Continued advances in improved electrical insulating materials make possible the reduction in size of motor frames. A new classification of motor frames is expected. A new evaluation of performance requirements will be necessary.

2. Hog-Feeding Equipment

Extensive testing of low-power feed mills has been completed. A publication is being prepared describing the results. Mills were tested grinding oats, wheat, and shelled corn. The tests completed suggested that it will be possible to isolate several of the parameters involved in hammer mill grinding to select the most efficient design. The power consumption per ton ground remained essentially constant for varying grinding rates.

3. Poultry Feeding Equipment

The medium-pressure pneumatic feed conveyor with the simple, low-cost auger feed injector has continued to perform satisfactorily. Units are being made commercially. Numerous inquiries have been received from individuals and manufacturing companies for information on this system of feed conveying. A Farmers' Bulletin has been prepared describing the construction and operation of the system. At Beltsville, the digital time-of-day egg recorder designed and installed last year has been used with low-pressure (2 grams) switches in 813 cages. In a 55-day test the system was 93 percent accurate in recording time of egg lay.

N. Electric and Solar Equipment for Environmental Control

1. Equipment for Poultry Environmental Studies

At Beltsville, in cooperation with Poultry Research Branch, the fourth year of a 5-year genetic selection of laying stock responsive to less than a 24-hour day cycle was completed in recently developed environmental facilities.

Percent hen-day egg production was 3 percent above the randombred control for the F3 generation of White Leghorns maintained under 18-hour "short-days". This is somewhat less than the 5 percent difference noted in the

previous generation. Egg production of the 24-hour population continued to increase to a level of 82.8 percent, 6.6 percent above the control during the past year. The 18-hour population continued to mature approximately one week later than the 24-hour population. Differences in other economic trait were small. An electronic data recording system has been developed for use in both houses (18-hour and 24-hour) during the past year. This system is designed to record the time of lay of each egg in an attempt to obtain complete information on the ovulatory sequences of the birds under both environments. This information is punched directly on an 8-channel tape (IBM format) for analysis.

Work was completed on egg sensor mechanisms used with the recording system. With birds in individual cages, a precision snap-action switch with low (2 gram) actuation design resulted in 93 percent accuracy in a 55-day test on 813 cages.

Nine Air Velocity-Heat Tolerance Tests were conducted during this reporting period. Each test involved 12 broilers held at various constant air velocities and subjected to a few hours of heat stress. When air temperatures did not exceed 105° F., heat stress was alleviated by higher air velocities, i.e., the rates of increase and the maximum values of body temperature and respiration rate were less at the higher than at the lower air velocities. More feed and less water were consumed at the higher than at the lower air velocities, but body weights were not affected. When air temperatures were increased above 105° F., the higher air velocities appeared to increase heat stress, i.e., the body temperatures (and in some cases the respiratory rates) increased more rapidly, and the survival times were less at the higher than at the lower air velocities. Heart rates in heat stress were not affected by air velocity, but at moderate air temperatures the rates were greater at the higher than at the lower air velocities.

2. Equipment for Swine Environmental Studies

The research on buildings and equipment for efficient swine production, including the utilization of heat pumps, has been continued in cooperation with the Virginia Agricultural Experiment Station. Two tests were conducted during the past year--one a summer test and the other a winter test. For both tests, temperature extremes in the closed building were controlled by operation of the heat pumps instead of maintaining a constant temperature of 65° F. Two fans were used to provide ventilation at a maximum rate of about 10,000 c.f.m. (About 100 c.f.m. per animal).

During the summer test, it was found that cooling by both heat pumps was required to maintain room temperature below 85° F. with 98 animals in the closed building when outside air temperature was above 85° F. and ventilation fans were not operating. Results on average daily gain and feed conversion with 9, 11, 13, and 16 animals per pen on each floor type closely paralleled

data for previous tests. Fully slotted, 1/2-slotted, and 1/4-slotted floors were used in the test. On the other floors, the degree of cleanliness was relative to the percent of slotted area in the respective pen.

For the winter test, the fully slotted floor in semi-controlled environment was converted to 1/2-slotted thus making floors in both the closed and 1/2-open buildings the same. Again, animals at densities of 9, 11, 13, and 16 per pen were placed on each floor type. With 98 animals it was necessary to furnish a very limited amount of supplemental heat to maintain temperature above 55° F. Average daily gain and feed conversion data were similar to that obtained for previous tests. It was found that 16 hogs could be raised in the same size pen as 9 with a slight decrease in gain per animal which might not be significant. Pens with 1/2-slotted floors in the closed building remained cleaner during the test than others with 1/4 of the floor slotted or in pens in the half-open building.

3. Milk Cooling Equipment on Farms

Investigations at Beltsville, Maryland, in cooperation with Dairy Research Branch, were continued to determine the effect on raw milk quality of differing rates of cooling in mechanically refrigerated farm bulk tanks. A system was devised wherein milk of differing levels of microbial contamination can be studied under exactly comparable tank cooling conditions. Studies have been initiated to evaluate the effects of varying cooling rates on the normal raw milk supply from the farm, both alone and with the addition of microbial contaminants having specific relation to food deterioration or public health. Preliminary results indicate that, whereas considerable relaxation of current cooling requirements might be adequate for maintenance of quality in the average grade A raw milk supply, it would not prevent an undesirable population increase resulting from the outgrowth of a massive psychrophilic contamination. The multiplication of Staphylococcus aureus, however, is adequately inhibited at a cooling rate as slow as that which required 3 hours to cool the first milking in the tank to 50° F.

0. Research Instrumentation

In cooperation with the Poultry Branch, a digital event recorder for time of lay was developed and installed in the poultry facility at Beltsville. Preliminary 55-day test data indicated 93 percent accuracy when used with 813 caged layers. Record information is printed for local readout and punched on paper tape for computer analysis. With hens in modified individual sloping floor cages, each egg rolls to the extended front of the cage floor and mechanically closes an electrical switch. Each switch is connected to the recorder by two wires. One wire is common to all switches. Once an hour the recorder scans the switches in sequence and punches on paper tape the coded numbers of the electrically closed switches. After the first egg in each cage is recorded each day, no additional records for that cage will

be entered in the recorder until the eggs are removed and the recorder reset. A digital clock provides exact time of scanning and punched time data. In addition to the punched tape, the recorder can print a numerical record on adding machine tape. The recorder can be activated manually to determine either the complete list of switches closed since the last egg gathering, or the stored information on switches closed. One switching or scanning unit is used for each 500 birds. Each scanning unit has six wires (telephone-type cable) to the master recorder and requires separate 120-volt power. In the event of power failure, a battery operates the clock to maintain time for about 3 hours. Upon resumption of power, regular scanning is automatically resumed with only loss of exact event-times during the outage.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

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II. NUTRITION, CONSUMER USE, AND UTILIZATION RESEARCH

NUTRITION AND CONSUMER USE RESEARCH Consumer and Food Economics Research Division, ARS Human Nutrition Research Division, ARS

Problem. The assortment and characteristics of food available to consumers change constantly with the adoption of new practices of production, processing, and marketing. Changing constantly also, as nutrition science advances, is our understanding of the nutritional needs of man and the manner in which these needs can best be met by food. To help meet the Department's responsibility to advise consumers on the quantity and variety of foods that will assure maximum benefit and satisfaction, research must continue on the nutritional requirements of persons of all age groups, on the nutrient and other values of foods, and on ways to conserve or enhance these values in household and institutional preparation and processing.

The kinds and amounts of foods consumed by different population groups and individuals must be determined periodically by surveys so that the nutritional adequacy of diets can be evaluated. Information on food consumption and dietary levels provides the guidelines needed for effective nutrition programs. This information also furnishes the basis for market analyses for different commodities and for development and evaluation of agricultural policies that relate to production, distribution, and consumer use of food.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program of research concerned with (1) nutritive and other consumer values of raw and processed foods as measured by chemical or physical means and by biologic response; (2) effects of household practices upon the nutritive values and inherent qualities of foods, and the development of improved procedures for household food preparation, care and preservation; (3) nutritional appraisal of food supplies and diets of different population groups; and (4) development of guidance materials for nutrition programs.

The research is carried out by two divisions of the Agricultural Research Service -- the Human Nutrition and the Consumer and Food Economics Research Divisions. Most of the work is done at Beltsville and Hyattsville, Maryland; some is done under cooperative, contract, or grant arrangements with State Experiment Stations, universities, medical schools, research institutes, and industry. The total Federal scientific effort devoted to research in these areas is 72.6 man-years. It is estimated that 13.0 scientific man-years are concerned with studies related to animal products.

Human metabolic studies and the related exploratory and confirmatory studies with experimental animals and microorganisms concerned with defining human requirements for nutrients and foods are not reported on a commodity basis,

though some of the work is applicable to this report. This basic nutrition research represents a total Federal effort of 21.1 scientific man-years and is described in detail in the report of the Human Nutrition Research Division. Certain aspects of this research related to animal products are considered briefly in this report.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Nutrient and Other Consumer-Use Values of Animal Products

1. Beef. Laboratory work was completed for a study of the effect of broiling temperature and degree of doneness upon color and tenderness of seven beef muscles. The muscles studied were: from the chuck, triceps brachii and serratus; rib, longissimus dorsi; loin, longissimus dorsi and psoas major; round, semitendinosus, biceps femoris and semimembranosus. Changes in color and tenderness due to the various cooking procedures are being evaluated in relation to such characteristics of the raw meat as fat, moisture, and myoglobin content, pH, shear press, and Hunter color values. The beef cuts came from beef animals of known history and were representative of those in regular markets. The work was carried out in cooperation with the North Carolina State University at Raleigh. The cooperators were responsible for selecting the animals, providing carcass data, and making determinations on the raw meat immediately post slaughter. The data are being prepared for publication.

2. Pork. A contract was executed with the University of Missouri at Columbia, for a study of the fatty acids of uncooked, cooked, and cured-cooked pork as part of a program to evaluate the fatty acid composition of cooked meat. The data should provide a basis for estimating the variations in fatty acid content within the carcass (picnic, loin, belly, or ham) and within a specific cut or location (covering, intermuscular or intramuscular fat in the lean meat). In addition, data will be obtained on the phospholipid and nonphospholipid fractions from the lipid of the lean, since these may be affected differently by cooking and curing plus cooking.

As part of the program to determine effects of the use of pesticides on nutritive values of foods, 16 livers and loins were obtained from hogs raised (4 each) on a pesticide free diet, and diets containing heptachlor, malathion, and DDT. The livers and lean muscle (longissimus dorsi) were samples for pesticide residue analyses and for nutrient analyses including fatty acid composition of the total lipid and of the phospholipid fraction, thiamine, vitamin A (livers only) and for nine mineral elements. Comparable loins will be cooked to obtain data on the effect of cooking on the changes in amount and distribution of the pesticide residues in fresh pork loin and shoulders and in hams and bacons cured and smoked by a commercial firm. Cooking drippings will be included in the study. This research is being done in cooperation with the Animal Husbandry and Entomology Research Divisions.

Studies were completed on the effects of cover fat and degree of marbling of cured hams on their composition and on palatability of the hams, baked and

unbaked. In order to obtain comparable cuts, 24 cured and smoked hams representing right and left sides, were obtained from the University of Illinois. The hams were selected for high-, medium-, and low-cover fat, and high and low levels of marbling. Baking resulted in higher percentages of lean and lower percentages of subcutaneous fat, but had no appreciable effect on the percentages of intermuscular fat, bone, skin, and waste. The proportion of total solids in the whole ham did not change significantly with baking, the protein and ash percentages increased, and lipids were lost to the drippings (about 25 percent). The percentages of most nutrients in the separable components were higher in baked than in unbaked hams. Few differences in the physical and proximate composition of unbaked and baked hams were found that were attributable to cover fat or marbling.

Palatability characteristics of mild-cured, "fully cooked," smoked hams representing the three levels of cover fat thickness and the two of marbling (see above) were not associated with carcass fatness. Hams were trimmed according to accepted commercial practices before curing. Taste panel ratings were obtained for color, juiciness, and flavor of ground lean meat and were sampled at room temperature (72° F.), refrigerator temperature (50° F.), and the customary serving temperature for hot meat (130° F.). Differences in color, juiciness, or flavor were not consistent with fatness in hams sampled as prepared for serving, either processed, "fully cooked" or after baking at 350° F. oven temperature to 130° F. internal temperature. Meat from the baked hams was less juicy and more flavorful than that tested without additional heating. Total cooking losses were about 14.5 percent with about one-half as cooking drip. A manuscript presenting these data has been accepted for publication in Food Technology.

3. Poultry. A study on the possible changes in nutrient composition of eggs and in the palatability of the meat of hens associated with the use of the pesticide, malathion, is ongoing under contract at the Food and Drug Research Laboratories, Inc. at Maspeth, New York. Malathion is used to control lice and usually is applied as a dust on the birds and in the pen. For the purposes of this study, to insure uniform exposure to the pesticide by the experimental birds, malathion was incorporated in the diet at levels of 0, 100, and 1,000 ppm. There were some malathion residues in the livers but not in the lean meat of birds fed at the 100 ppm. level during preliminary studies. Malathion is rapidly metabolized and it is not anticipated that residues will be present above the 4 ppm. permissible tolerance in meat from the hens fed at the 1,000 ppm. dietary level. The 8-week test period has been completed during which hens were slaughtered at regular intervals to provide palatability samples, and the eggs from all hens were collected. Inspection of early data did not show discernible effects of malathion on body weight, feed efficiency, or egg production during the 8-week period. Approximately half of the nutrient analyses of the eggs have been completed. Palatability evaluations will be made on white and dark meat from birds roasted as fresh market birds and after 6 months storage at 0° F.

Major emphasis continued to be placed on studies of the effect of cooking time and temperature upon eating quality, safety, and yield of cooked turkey meat. Turkey roasts of light meat and of dark meat were cooked to internal temperatures

of 165°, 175°, 185°, and 195° F. by roasting at oven temperatures of 250°, 325°, and 400° F. and by braising at oven temperatures of 250°, 300°, 350°, and 400° F. Higher oven temperatures shortened the roasting time but did not affect eating quality or yield of cooked meat. Braising (oven cooking in a closed container) further shortened cooking times and resulted in juicier meat and lower cooking losses than roasting. Optimum doneness of turkey roasts was achieved at a final internal temperature of 165° to 175° F. for light meat roasts and of 175° to 185° F. for dark meat roasts when roasted and at 165° F. when braised. These data are being prepared for publication.

When whole, stuffed turkeys are cooked slowly, thigh and breast meat are done at a lower meat temperature than when they are cooked more quickly. At oven temperatures of 200° and 325° F., desirable doneness is reached at end-point temperatures in the inner thigh of 165° F. and 180° F. respectively. The time required to reach comparable stages of doneness at 200° F. and 325° F. oven temperatures was 1 hour per pound, or 24 hours for a 24-pound turkey at 200° F., as compared to 7 hours at 325° F. to reach a thigh temperature of 180° F. In the 200° F. oven, the stuffing remained an average of 7 hours in the range of temperatures that permit bacterial growth (45° to 120° F.). Stuffing temperature at the end of cooking was usually under 160° F. and bacteria were recovered from the stuffing during and after heat treatment in 14 out of 16 inoculated turkeys at the end of cooking at 200° F. Cooking at 450° F. in foil reduced the cooking time to about 10 minutes per pound or 4 hours for a 24-pound turkey, but the eating quality of the light and dark meat was not as good as that cooked at 325° F. and, the stuffing did not reach a safe temperature in 20 out of 24 turkeys by the end of the cooking period. Turkeys cooked at either 200° or 450° F. might offer a hazard from certain bacteria if contaminated prior to cooking and are not recommended for use with stuffed turkeys. These data were obtained from research under contract with Purdue University at Lafayette, Indiana. Manuscripts presenting the data have been prepared for publication.

Alternate procedures for thawing and cooking whole turkeys have been developed for use in the School Lunch Program. Cooking of whole turkeys is both time-consuming and a potential health hazard in large quantity food preparation. Also, in School Lunch programs, both time and space for thawing whole turkeys have been problems. Preliminary findings indicate comparable eating quality and yield from roasting of either frozen or thawed turkey halves or pieces. Cutting turkeys into halves decreased thawing time to about 18 hours, breast pieces required about 24 hours, and legs, 14 to 15 hours in the refrigerator, as compared with several days for thawing a whole frozen turkey. To effect the savings of time in thawing, the pieces must be packaged so they can be separated easily, preferably packed in layers with two sheets of paper between layers.

Research has been initiated to explore the relationship of the protein constituents of turkey breast and thigh muscles to juiciness and texture of the cooked meat. These palatability factors are of major importance in determining consumer acceptance of turkey. Beltsville small white turkeys are being studied

fresh and after frozen storage comparable to household practice. Disc electrophoresis is being used to separate protein fractions in water extracts of muscle proteins. If the results prove promising, attention also will be given to further separation and characterization of the proteins.

B. Nutritional Evaluation of Animal Products

1. Heated and oxidized fats. Research on fats and oils mildly oxidized by aeration at 140° F. for 40 hours has continued under a research contract with Columbia University at New York City, and has been extended to include information on the response of rats to soybean oil. Mild oxidation has consistently resulted in longer survival for rats fed mildly oxidized olive oil, corn oil, and soybean oil than for those fed the fresh oils. In contrast, survival was similar for rats fed fresh and oxidized fats (lard, beef, chicken, and butter) and did not differ from the results obtained with the three oxidized oils. The results obtained suggest that further research is warranted to determine the cause for the reduced survival observed with the fresh oils.

A report of some of the findings from this research, "Nutritional effects of some fresh and mildly oxidized animal and vegetable fats" was presented to the American Oil Chemists Society in April 1966. A paper entitled "Longer survival of rats fed oxidized vegetable oils" will be presented at the VIIth International Congress of Nutrition in Hamburg, Germany, August 1966.

2. Dietary fat and cholesterol synthesis. The body continuously synthesizes cholesterol, which is essential for normal function but which may be associated with certain pathological conditions. The rate of cholesterol synthesis may be significantly influenced by diet. In recent studies at Beltsville, the influence of type of fat on cholesterol synthesis was investigated. When rats were fed a diet containing 20 percent corn oil, cholesterol synthesis was considerably greater than when the diet contained 20 percent beef tallow. In spite of marked differences in rate of synthesis, no differences were observed in the levels of cholesterol in the serum. A manuscript presenting these data has been submitted for publication.

3. Proteins versus amino acids. When complete amino acid mixtures are used to replace protein in the diet of rats, less rapid rates of growth are generally found than with high quality protein diets. In an attempt to explain the differences observed, radioactive tracers were used to study the utilization of glucose by rats fed these two sources of nitrogen. From this investigation, it appears that the rats that are fed a diet containing protein free amino acids break down glucose differently than those that are fed a diet containing protein. When rats were fed the amino acid diet the direct oxidation of glucose was increased and even though this diet supplies high levels of all known essential nutrients, it fails to maintain normal metabolism. A paper reporting the results of this study has been accepted for publication in the Journal of Nutrition.

4. Immunoproteins and protein status. A project has been initiated to determine the relationship of immunoproteins to protein status and amino acid intake. This project, to be carried out under a research grant with Iowa State University at Ames, will study antibody formation by rats fed proteins from various sources, such as corn, rice, soy, wheat, or egg. The proposed research should aid in establishing the sensitivity of antibody production to protein or selected amino acid deficiencies and further our understanding of the role of food proteins in maintaining a healthy and normally functioning body.

5. Nutrient interactions. Findings from studies to determine the nutritional value of various components of milk emphasize the importance of understanding possible interaction of various dietary components. The diets studied contained milk protein with various combinations of fat, as butter oil or corn oil, and carbohydrates, as lactose or cornstarch. When the diet included butter oil and lactose, calcium absorption by rats was much greater than with butter oil and cornstarch, corn oil and cornstarch, or corn oil and lactose. Retention of calcium, however, did not increase with the increased absorption; the excess calcium apparently was excreted in the urine. A high incidence of kidney stones occurred when the diets contained butter oil and lactose; no kidney stones were found with the diets containing starch. The incidence found with lactose and corn oil was low and did not differ significantly from the cornstarch diets. More research is needed to establish the mechanism responsible for the differences observed. A paper reporting the results of this research is being prepared for publication.

A PL 480 study has provided further evidence that the effects of various dietary components may differ markedly with the food pattern consumed. Diets patterned after the protein-fat combinations typical of those in three regions of India -- North, Central, and South -- were fed to rats to investigate the influence of diet on fat metabolism. Omission of the vitamin and mineral mixtures commonly used to assure adequacy of these nutrients in the diet of the rat resulted in lowering the high cholesterol observed with the diet combination of high animal protein and saturated fat that is consumed in North India. Omission of these fortifying mixtures caused an increase in serum cholesterol when rats were fed the chick pea-sesame oil diet of Central India. Omission from the bean-coconut oil combination of South India resulted in extremely high levels of blood cholesterol and neutral fat. Thus, not only the kind and amount of dietary fat was important and the kind and amount of protein and carbohydrate but also the relative amounts of the minerals and vitamins. These studies are to be extended to confirm these findings and to seek an explanation for the results obtained.

C. Tables of Food Composition

1. B-vitamins and trace elements in foods. Summarization of data and derivation of representative values are nearing completion for a publication on

the content of pantothenic acid, vitamin B₆ and vitamin B₁₂ in foods. The values will be given in terms of milligrams of the nutrient per 100 grams of edible portion and per 1 pound as purchased for each food item.

Also nearing completion is a preliminary table summarizing the data for 22 trace elements in foods arranged in 15 food groups. Data representing over 6,500 food samples analyzed for 1 to 22 trace elements have been reviewed, recorded on cards for punching and sorted by specific food. This table is particularly useful for indicating foods and food groups for which data are very limited or are conflicting.

2. Vitamin E. A review of the vitamin E content of more than 5,000 food and feed items used for human and/or animal consumption was completed and published by the University of Wyoming at Laramie. This review was proposed and partially supported by the Human Nutrition Research Division. A total of 455 references were reviewed and fewer than 40 contained information on individual forms of tocopherols. The review was instigated by the increased recognition given to the importance of the tocopherols in metabolism of polyunsaturated fats and the extent of their use as naturally occurring antioxidants.

D. Food Consumption and Diet Appraisal

1. 1965 nationwide survey. Collection of data from the more than 15,000 households and 13,000 individual family members cooperating in the nationwide survey of food consumption in the United States is now complete. Tabulation of the data on households and preparation for tabulation of the data on individuals are in progress.

Preliminary review of the household data shows that family expenditures for food averaged \$33 a week in the spring of 1965. Of this, \$27 went for food bought and used at home, \$6 for meals and snacks eaten away from home. Home-produced and other foods for which no direct money outlay was made were valued at \$2. The money value of the food used averaged \$10.65 per person.

The total money value of food per family was 17 percent greater in the spring of 1965 than in 1955 when a similar survey was made. Most of the increase can be attributed to higher food prices but there was also a substantial increase in spending by farm families for food bought and eaten away from home. Their expenditures for eating out nearly doubled in the 10-year period and took 11 percent of total food money in 1965 compared to 7 percent in 1955. A report of the preliminary findings of the money value of food of households is being prepared.

Later, information will be available on the types and quantities of foods used by families in the spring of 1965. There will be information on approximately 250 foods--the percentages of families using the foods, average amounts and the money value of the food used. Where pertinent, data will be shown separately for purchased, home-produced, and Federally donated food. Publications will be prepared on dietary levels provided by the foods used. Similar information will be published also for the 4 seasons. For individual family

members, data will be reported for about 20 different sex-age groups, for the U.S. total and probably for 2 regions.

2. Diets and nutriture of preschool children. A study was initiated to determine the nutritional situation of children, 2 and 3 years of age, in low-income families in Hawaii. Children from low-income families will be compared with those from higher income families with similar ethnic backgrounds. Biochemical, clinical, and psychomotor tests will be used to assess nutritional state. Correlations will be sought with social and economic characteristics of the child's family. The study will be done under a Cooperative Agreement by the University of Hawaii.

3. Household practices in homefreezer management. Preliminary review of the data collected during July 1964-April 1965 from 240 urban and 242 farm families in and near Fort Wayne, Indiana, showed that of the reasons given by urban families for acquiring a homefreezer, about 40 percent were related to convenience--e.g., to have food on hand and to save shopping time. About 40 percent were related to economy--e.g., to buy meat by the side or quarter and to freeze local and home-grown fruits and vegetables in season. The remaining 20 percent were miscellaneous reasons. The reasons given by farm families were similar to those by urban families.

Fewer urban than rural households, 60 percent vs. 70 percent, kept the temperature of the storage areas in their freezers at the recommended temperature of 0° F. or below. Twenty-five percent of the freezers in urban households and about 35 percent of those in farm households were equipped with a thermometer.

Reports of these and other findings from the study are now being prepared as articles for publication in Family Economics Review. Preparation of a more comprehensive report will follow.

4. Nutritive value of national food supply. Estimates of food energy (calories) and selected nutrients provided by the per capita food supply are calculated each year from data on apparent civilian consumption, retail basis, developed by the Economic Research Service. The estimates indicate that for the past 10 years the level of food energy has remained around 3,150 calories per capita per day--about 10 percent lower than in 1909-1913. This lower calorie level is the net result of about a 25 percent decrease in carbohydrate available for consumption, a 15 percent increase in available fat and a slight decrease in available protein, between 1909-1913 and 1965. This shift in the composition of the food supply caused the percentage of total calories furnished by carbohydrate to drop from 56 to 47 and the percentage of total calories furnished by fat to rise from 32 to 41. The percentage of total calories furnished by protein remained at about 12.

5. Nutritive content of school lunches. A nationwide study of the nutritive content of type A school lunches as served to sixth graders was initiated in cooperation with the School Lunch Division, Consumer and Marketing Service. Plans call for the collection and analysis of 20 lunch composites from 300 schools located in 19 states in five geographic regions. The objective is to

provide data needed in evaluating the type A pattern. Because the pattern specifies the minimum amounts of foods required but does not specify maximum amounts that are allowed, the fat content of the lunches is of special concern.

E. Support for Food and Nutrition Programs

Developments in nutrition research continue to be studied and interpreted for application to problems in food selection and food use.

In anticipation of the expansion of child feeding programs, meal patterns for breakfasts and dinners suitable for children of all ages, were developed at the request of the School Lunch Division, Consumer and Marketing Service. These meal patterns will serve as guidelines for planning meals to meet the needs of children for food energy and the major nutrients. The patterns may be used independently or in conjunction with the type A lunch pattern.

To help promote better nutrition among low-income families, NCU food specialists and nutrition specialists cooperated with other Department agencies in the preparation of a teaching kit "Food for Thrifty Families." The kit consists of an adaptation of the "Daily Food Guide" and a series of 20 fliers that contain information on nutrition and simplified recipes for donated foods and food relatively low in cost. Animal products included are nonfat dry milk, cheese, poultry, eggs, and meat products.

A new bulletin "Poultry in family meals" was added to the series of 11 being prepared to help consumers use basic food commodities. These bulletins bring together research findings on food preparation, selecting and buying food, food storage, nutrition, and menu and recipe suggestions for family meals.

The bimonthly publication of Nutrition Program News was continued. This publication reaches about 7,000 workers in nutrition and related fields. Talks to groups involved in community nutrition programs, radio tapes, and consultant help and participation in conferences contributed to coordinating and strengthening of nutrition programs.

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DAIRY UTILIZATION - FOOD

Eastern Utilization Research and Development Division, ARS

Problem. Utilization research on milk is conducted in order that the milk products industry can defend and expand its markets, and to reduce price support expenditures by bringing commercial demand for milk products into better balance with supply.

The importance of this research can be gauged from the vast size of the industry, for dairying is one of the largest segments of American agriculture, milk is the base of an enormous processing and distributing systems, and milk is nutritionally most important:

Farm cash receipts from milk and cream marketings provide more than five billion dollars a year, about 13% of all cash receipts from farm products; only livestock marketings are greater.

The retail value of milk is eleven billion dollars a year.

Milk production is over sixty million tons a year; dairying is first in farm income in 9 states, second in 6, third in 7 and important in all the rest.

The farmer's share of the consumer's food dollar spent on dairy products averages 44 cents whereas the average value for all foods is about 38 cents.

Milk contributes about a quarter of the protein in the American diet and most of the calcium, phosphorous and vitamin B₂.

Per capita consumption of milk in the United States has been decreasing steadily and is now about 585 pounds per year, well below that of many foreign nations, including Finland, Ireland, New Zealand, Canada, Australia, Sweden, Denmark, Norway, Switzerland, Belgium and the United Kingdom, all of which consume more than 800 pounds per capita. It is thus evident that there is opportunity to increase milk consumption, despite the tremendous variety of ways in which our populace can spend its money, and the freedom it has in deciding what or what not to buy.

Even though milk production is only about six per cent above commercial demand this surplus has led to substantial government price support and related programs. Expenditures for these have ranged from 300 to 700 million dollars a year during the past five years.

Milk is a biological secretion and a valuable human food but basically it is a complex mixture of complex chemical substances. Finding out what these substances are, what their individual properties are, how to speed up, slow down, direct and, in sum, control their reactions is vital to practical

development of new markets based on new products or processes, improvement in existing products or processes, or cost reduction in existing processes.

The lead time to such development may be several years. This kind of research is recognized as a province of government laboratories, state and national, since it is basic to the whole milk industry and the results are freely available to all. Outside public research, such studies could be undertaken only by the very largest industrial laboratories and these would, quite understandably, disseminate results only as they saw fit and doubtless for their own profitability.

Government properly sponsors only research and development that the milk industry can not be expected to do for itself: projects of long duration requiring larger resources, having a substantially greater element of risk or, as with basic research, lacking the prospect of full private exploitation.

Government research and development on processes and products normally proceeds to such a technical stage that industry can logically decide whether or not to adopt them and, when adopted, government may properly also provide technical advice during the first stages of commercial application.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving chemists, biochemists, microbiologists, food technologists and engineers engaged in basic research on the composition and properties of milk and in applied research directed to the development of new and improved dairy products and processing technology. The Department's research facilities are located in Wyndmoor, Pa., Washington, D. C., and Beltsville, Md. In addition, arrangements have been made for conducting some Division research work at Brandeis University, Waltham, Mass., beginning in F.Y. 1967.

The Federal (USDA) scientific effort devoted to research on milk totals 63.1 scientist man-years which includes 6.8 scientist man-years in the domestic contract and grant research program. This effort is distributed as follows:

(a) Chemical Composition and Physical Properties. Research at Wyndmoor and Washington totals 22.5 scientist man-years, devoted to the interaction of milk proteins in solution; mammalian and bacterial ribosomal nucleic acids; composition and structure of protein components of milk by the use of enzymes; the behavior of milk enzymes; properties of the various caseins present in milk; allergens in milk; and sol-gel transformations in milk concentrates. Contract research at the University of Maryland, College Park, (0.5 scientist man-year) deals with the relation of milk fat composition to the diet of the cow. Contract research at the University of Minnesota, St. Paul, (0.5 scientist man-year) is concerned with the possible role of genetics in affecting the heat stability of individual milks. Contract research at Ohio State University, Columbus, (0.6 scientist man-year) deals with the calcium phosphate complex in milk and milk concentrates. Grant research at North Carolina State University, Raleigh, (0.7 scientist man-year)

deals with physical changes in milks due to steam injection. In addition, research sponsored by the Department under PL-480 grants is in progress at the following foreign institutions:

1. Indian Institute of Science, Bangalore, India, on phosphoproteins of milk (5 years, 1963-1968).
2. National Dairy Research Institute, Karnal, Punjab, India, on the proteose-peptone fraction of milk (5 years, 1963-1968).
3. Israel Institute of Technology, Haifa, on the formation of unnatural nucleic acids (3 years, 1965-1968).
4. Institut National de la Recherche Agronomique, Paris, France, on the non-protein nitrogenous substances formed from milk proteins during various industrial treatments (5 years, 1961-1966).
5. Centra de Recherches sur les Macromolecules, Strasbourg, France, on the subunit structure of nucleic acids (5 years, 1961-1966).
6. University of Uppsala, Uppsala, Sweden, on the development of methods for purification of milk proteins and studies of their structure (5 years, 1963-1968).
7. Instituto Nacional de Tecnologia, Rio de Janeiro, Brazil, on the structure and properties of proteolytic enzymes (5 years, 1961-1966).
8. University of Graz, Graz, Austria, on the structures and interactions of nucleic acids by means of small angle X-ray studies (5 years, 1966-1971).

During the year, research at the Institut National de la Recherche Agronomique, Paris, France, on the proteolytic activity of rennin on casein was completed, as was also research on selected enzymes of milk at the National Institute for research on Dairying (University of Reading), Shinfield, Reading, England.

(b) Flavor. Research at Washington involves 3.0 scientist man-years devoted to the study of stale flavor in sterile milk. In addition, grant research at the University of Maryland (0.5 scientist man-year) is devoted to milk flavors and flavor precursors that are derived from pasture or dry feeding practices. Grant research at Oregon State University, Corvallis, (1.0 scientist man-year) is directed to isolation and identification of specific flavor contributing compounds in butter. Grant research at the Pennsylvania State University, University Park, (0.9 scientist man-year) is devoted to study of the origin

and control of lactones, methyl ketones and their precursors in milk as a basis for the development of procedures to avoid the undesirable flavor effects of these substances in milk products.

In addition, research sponsored by the Department under PL-480 grants is in progress at the following foreign institutions:

1. National Dairy Research Institute, Karnal, Punjab, India, on sulfur compounds in milk and milk products and their relation to cooked flavors and oxidative stability (5 years, 1963-1968).
2. Biochemical Institute, Helsinki, Finland, on dietary factors controlling flavor in milk (5 years, 1964-1969).

(c) Color, Texture and Other Quality Factors. Research at Washington totals 2.0 scientist man-years devoted to investigation of the allergens of cow's milk. Contract research now beginning at the Pet Milk Company, Greenville, Illinois, will deal with the stability of commercial fluid milk during refrigerated storage over periods great enough to permit the radioactivity of iodine-131 to decay to harmless levels.

(d) Microbiology and Toxicology. Research at Washington involves 1.1 scientist man-years devoted to study of the chemical and physical mechanism of the development and maintenance of heat resistance and dormancy in bacterial spores. Contract research at the University of Wisconsin, Madison, (0.2 scientist man-year) is concerned with the effects of nonfat dry milk on bread yeast fermentation. In addition, research under a PL-480 grant is in progress at the U.P. Agricultural University, Pantnagar, India, on factors which influence the synthesis of dipicolinic acid in bacterial spores (5 years, 1966-1971).

(e) Technology - Process and Product Development. Research in process and product development totals 27.7 scientist man-years at Washington, Wyndmoor and Beltsville. Studies on the preparation of dry whole milk by the vacuum foam-drying process (Wyndmoor) and the foam spray-drying process (Washington) totals 18.3 scientist man-years. The development of improved dairy processing equipment involves 1.4 scientist man-years at Washington. Development of new cheese products involves 4.5 scientist man-years and new product development based on butter fat, 3.5 scientist man-years. Contract research at the Producers Creamery Company, Springfield, Missouri, is concerned with development of a commercial scale process for removing radioactive strontium from fluid milk. This contract, supported equally by the Eastern Division and the U. S. Public Health Service, involves a total of 3.8 scientist man-years.

Also, the Eastern Division is contributing support to a U. S. Public Health Service contract with the Chemical Separation Corporation, Oak Ridge, Tenn., for research on the removal of radioactive contamination by use of a moving resin bed; the USDA contribution is equivalent to 1.2 scientist man-years.

Additional research sponsored by the Department under PL-480 grants is in progress at the following institutions:

1. National Dairy Research Institute, Karnal, Punjab, India, on the isolation and use of milk coagulating enzymes for cheese manufacture (5 years, 1962-1967).
2. Kaira District Cooperative Milk Producers Union, Ltd., Anand, India, on the addition of nonfat dry milk solids to buffalo milk in the manufacture of hard cheese (5 years, 1961-1966).
3. College of Agriculture in Olsztyn, Olsztyn, Poland, on mechanisms of the cheese-ripening process (5 years, 1963-1968).
4. National Dairy Research Institute, Karnal, Punjab, India, on the role of starter bacteria and some genetic variants in the development of flavor during the manufacture of cheese (5 years, 1966-1971).
5. "Juan de la Cierva" Foundation for Applied Research, Madrid, Spain, on the thermal and related physical properties of milk and milk products (5 years, 1964-1969).
6. Technical University Berlin, Berlin-West Germany, on chemical changes at the surface of fat globules in foam-dried whole milk (4 years, 1963-1967).

Research on the development of mutant strains of molds with increased ability to synthesize vitamin B in cheese, at the Institute of Dairy Industry, Warsaw, Poland, has been completed.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 88 scientist man-years is devoted to this area of research.

PROGRESS - USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties.

The application of optical rotatory dispersion and infrared techniques to the three known genetic variants of β -lactoglobulin suggests that the native protein has a structure consisting of 10-15% right-handed alpha helix, 35-40% beta conformation and the rest in a disordered state. This represents the first reported instance of beta structure in a native globular protein. The application of the circular dichroism technique to β -lactoglobulin provides data agreeing with the optical rotatory dispersion observations. Hence, β -lactoglobulin is the first protein of complex structure whose conformation in solution has become understood.

Studies on the structure of ribosomal ribonucleic acid (H-RNA) show that H-RNA from mammalian sources contains two components with molecular weights of two million and five hundred thousand, and bacterial H-RNA's have components with molecular weights of one million and five hundred thousand.

This basic research on the nucleic acid component of ribosomes is helping to describe the factors that control the synthesis of milk proteins.

In contract research at the University of Minnesota a maximum was found in the pH stability curve of bulk milk at pH 6.55 to 6.65. This maximum was eliminated if the skim milk was dialyzed against a salt mixture simulating milk salts. Thus an unknown dialyzable compound of milk apparently was responsible for loss of the maximum. Studies thus far have not shown a relationship between the heat stability of cow's milk and the genetic type of α_s or β -casein, apart from the rare α_s -casein type AA.

Continuing study of the enzymes of milk has resulted in the chromatographic separation of the four ribonucleases (A, B, C and D) and also their separation by disc electrophoresis. Major emphasis has been placed on ribonuclease B. Ribonuclease B contains mannose, glucosamine and galactosamine. Pancreatic ribonuclease B lacks galactosamine.

Digests of α_s -casein B and α_s -casein C show one peptide with different amino acid composition. It is suspected that the pair of difference peptides have the glycine-glutamic acid substitution that has been found by amino acid analysis. The α_s -casein type A is most similar to the B type but several difference peptides were found, as expected from the amino acid compositions. Similar studies done with β -casein types A, B, and C were less clear-cut.

The components of kappa-casein differ chiefly in carbohydrate content. Kappa-casein is the principal agent for stabilizing the colloidal casein in milk and although the mechanism of stabilization is not yet completely known it is clear that mechanisms which have been proposed are incorrect. Kappa-casein appears to interact strongly with polyanions, suggesting that the structure of kappa-casein is considerably different than the structure of other proteins. Small casein micelles contain a higher percentage of kappa-casein than large ones do. This suggests that kappa-casein may be in the surface of the micelle.

Two additional variants of β -casein were discovered by typing at pH 3.0. The detection of polymorphisms in milk proteins depends on the sensitivity of the method of typing that is used. As new techniques for this purpose are developed it is likely that new variants will be discovered. Already, improved techniques show the existence of a genetic variant of the red protein (lactotransferrin) in the milk of individual cows.

Research on the fat-plasma emulsion of cow's milk shows that during reconstitution of dry milk the fat-solid system in milk powder fractionates at the air-water interface and forms a fat-protein film which prevents the wetting of further added milk powder.

Grant research at the Ohio State University Research Foundation, Columbus, indicates that nuclear magnetic resonance spectroscopy is a useful tool for studying bonding within milk micelles. The binding of kappa-casein by simple anions produced marked changes in the NMR spectrum of kappa-casein. When

α_s -casein interacted with simple anions similar phenomena were not observed.

When whole milk and a 3-to-1 concentrate were sterilized at 141°C. for seven seconds, or at 149°C. for one second, the phosphatase, lipase and xanthine oxidase were inactivated. Only phosphatase showed reactivation upon storage. The degree of reactivation of phosphatase depended on the time, storage temperature and preheating and sterilizing conditions. When the whole milk and concentrate were homogenized at 4000 p.s.i. after sterilizing no enzymes showed significant reactivation.

Grant research at North Carolina State University, Raleigh, continues to demonstrate that there are severe strains at the steam-milk contact point in steam injectors. No thermal sensor has yet been found able to withstand the strain imposed by the entering steam. These difficulties demonstrate the highly dynamic conditions that exist in milk during steam injection heating.

Contract research at the Maryland Experiment Station suggests that cows receiving limited amounts of forage produced less fat than others, as shown by both total fat production and fat percentage in the milk. The average protein and solids-not-fat production and percentage composition showed no striking differences between the two groups of cows.

Investigations of the proteose-peptone fraction of milk under a PL-480 grant to the National Dairy Research Institute, Karnal, Punjab, India, show that heat treatment and sterilization (e.g. 115°C. for 10 minutes) caused a significant decrease in the proteose-peptone content of milk. A simple turbidity method has been developed for determining the amount of proteose-peptone, proteose alone and peptone alone in milk.

Research under a PL-480 grant to the Institut National de la Recherche Agronomique, Paris, France, on rennin activity shows that the action of rennin in clotting casein is notably specific. The clotting by rennin follows the splitting of a preferential bond, probably a peptide bond, and rennin probably needs a sequence of several amino acids on the casein peptide chain to recognize this bond. Rennin is not a typical protease for it is not inhibited by diisopropyl-fluoro-phosphate.

Research in progress in France under a PL-480 grant to the Centre de Recherches sur les Macromolécules, Strasbourg, on the subunit structure in nucleic acids, has led to the development of a general and rather simple method for the preparation of acid deoxyribonuclease and some other acid hydrolases. Acid deoxyribonuclease is shown to be a dimeric structure which undergoes allosteric interaction with its synthetic substrate bis(p-nitro-phenyl)-phosphate.

Fundamental studies under a PL-480 grant to the Instituto Nacional de Tecnologia, Rio de Janeiro, Brazil, on the relation of biological activity of proteins to their structure, show that hydroxyl radicals (provided by Fenton's reagent) almost immediately modify most of the trypsin. Fractionation of the reaction mixture gives two main components, one with little

activity. The second, more active, component is not homogeneous and can be further fractionated.

Research under a PL-480 grant to the Indian Institute of Science, Bangalore, India, on phosphoproteins of milk, led to the fractionation of the peptic peptides of cow and buffalo caseins. Ten components of these caseins were thus obtained and studies of the homogeneity and characteristics of these components are now going forward.

Investigations at Institut de la Recherche Agronomique, Paris, France, under a PL-480 grant, on the nonprotein nitrogenous substances formed from the protein during various industrial treatments of milk have shown that the heating of casein liberates at least two peptides. The nonprotein nitrogenous substances liberated by heat contain more phosphorous than those obtained by an enzymatic procedure, and part of this phosphorous is in an organic state. The formation of inorganic phosphate seems to be a second step of the degradation process.

B. Flavor.

Continuing research on the stale flavor of sterile concentrated and dry milks resulted in the discovery that the material kynurenine is a possible precursor of O-aminoacetophenone, which is in turn believed to be in part responsible for the stale flavor of concentrated and dry milks. Development of the color reagent, 2,6-dinitrophenylhydrazine of pyruvyl chloride (DNPHPC) continued, and its esters with primary, secondary and tertiary alcohols were prepared. Preparation of these esters will aid in evaluating the hydroxy-containing precursors of the lactones which form in heated milk and which are responsible for development of some of the stale flavor.

Application of gas chromatographic techniques in grant research at Oregon State University, Corvallis, has provided aromagrams of distillates of molecular and steam distillation of butteroil. The complex nature of butter flavor is indicated by the many peaks having unrelated odor characteristics. Some of the major peaks which have been identified are dimethylsulfide, delta and gamma lactones, methyl ketones and low molecular weight aldehydes, alcohols and esters. Many other flavor compounds remain to be identified.

Grant research at the Pennsylvania State University, University Park, on the origin of lactones in milk showed that the diet of the cow influences the lactone potential of the milk. Heat-treated corn diets gave 25% less lactone potential than normal diets. A quantitative procedure for determining lactones using gas liquid chromatography was developed and employed and a decrease in lactone potential in winter as opposed to summer milk was noted. This work indicates that the level of lactone potential in milk may be controlled by feeding practices.

PL-480-supported research at the Biochemical Institute, Helsinki, Finland, shows that cows maintained on a purified protein-free diet produce "zero" milk which serves as a basis for studying the origin of milk flavors. Milk production on the protein-free feed has increased with time. This "zero" milk contains the same nutrients as a milk from cows on normal feed. The

rumen contents of the test cows, on the basis of gas chromatographic determinations, are relatively poor in volatile substances with the possible exception of volatile fatty acids. The presence of characteristic flavor substances in milk--for example, the C6 to C12 lactones--could not be demonstrated in the rumen and it thus appears that the most important flavor components of milk are formed later on. Every day each cow gets 20 pounds of compressed briquets containing purified starch, cellulose, sucrose, and urea and ammonium salts, 8 pounds of a wet paste rich in cellulose and small amounts of corn oil and commercial preparations of vitamins A, D and E. Cellulose strips impregnated with silicic acid are used to improve rumination.

In research conducted under a PL-480 grant at the National Dairy Research Institute, Karnal, India, a simple and specific method for using N-ethyl maleimide was developed for estimating the free sulfhydryl groups in milk. Studies on the various ions indicate that cupric and ferric ions accelerate the rate of oxidation of the sulfhydryl groups to disulfide compounds. Hence, these metallic ions should not come in contact with milk and its products. Some of the components responsible for cooked flavor in milk were found to be dialyzable. Studies on the hydrogen sulfide content of milks show that thermal processing at high temperatures for long periods is likely to give products with hydrogen sulfide flavor and resulting poor consumer acceptance.

C. Color, Texture and Other Quality Factors.

The antigenic specificities of immunoglobulins from bovine serum, colostrum, milk, and pseudoglobulin from milk were compared by gel diffusion and immunoelectrophoretic techniques. The immunoglobulin of bovine serum and colostrum were shown to be identical. The immunoglobulin and pseudoglobulin from milk exhibited identical specificity but differed in electrophoretic mobility. A new method was devised for the electrophoretic fractionation of the castor bean allergen, CB-1A. With the new procedure the major and principal minor antigenic specificities of CB-1A were separated and estimated as 85% and 15% respectively. The previous conclusion that chemically distinct components of CB-1A contain similar or identical antigenic specificities was thus reaffirmed.

Investigations on castor bean allergens have been terminated.

D. Microbiology and Toxicology.

In continuing research on the occurrence of dipicolinic acid (DPA) in bacterial spores, spores treated with hydrazine were imbedded, thin sectioned, stained and observed in the electron microscope. No detectable structural differences were observed in electron micrographs of the hydrazine-treated spores as compared with the control. Chemical analysis showed no loss of calcium, phosphate, DPA glucosamine or ribonucleic acid. Germination of spores may be triggered by minute amounts of some unidentified substance. DPA is not released from the spores during electrodialysis, suggesting that it is held by covalent bonds or may exist in salt form in portions of the spore that are inaccessible to water.

Contract research at the University of Wisconsin on the use of nonfat dry milk (NDM) in continuous breadmaking indicates no correlation between the heat treatment of milk prior to drying and the amount of CO₂ produced in

ferments containing NDM. The pH influences carbon dioxide retention in dough and in baking; the most suitable pH range appears to be 4.0 to 6.0.

E. Technology - Process and Product Development.

1. Dried milk. Intensive study has continued on the cause of off-flavor found in foam spray-dried whole milk prepared in Washington during the summer months. In general, experiments tended to corroborate the idea that the greater air pollution in summer was responsible for the poor initial flavor of the product. Equipment for the analysis of volatile fractions from the foam spray-dried milk will be used to compare the volatiles from fresh, stale and "summer-flavored" product.

Near the end of the summer of 1965 some samples of foam spray-dried whole milk powder were produced with good initial flavor. With one of these samples the Economic Research Service again performed a consumer acceptance test using a panel drawn from Department employees. The results confirmed those obtained earlier: quality foam spray-dried whole milk apparently was as acceptable to consumers as fresh pasteurized whole milk from a commercial source. Foam spray-dried whole milk made by injection of low levels of liquid carbon dioxide into the concentrate before drying reconstituted with less foam formation.

Equipment for cooling the spray dried whole milk powder and packaging it in the absence of air made possible the packaging of a powder with less than 0.001% oxygen in the head space gas.

The foam spray-drying process has now been adopted commercially for the manufacture of nonfat dry milk of good quality. In the process, concentrates containing 60% or more of solids may be handled, in contrast to the usual 45%. The product is less fragile than conventional "instantized" nonfat dry milk and the entire procedure is more economical and produces a better product than the conventional process. The method can be used in making other dried products such as whey, ice cream mixes, malted milk, chocolate milk, phosphated milk for growing bacteriophage-free starter cultures for use in cheese making.

Continuing research intended to optimize the year-round production of whole milk powder from the continuous vacuum foam-drying process indicates that the mathematical model of the process is greatly facilitating the research by showing the response of production rate and product quality to process variables.

A possible solution to the problem of seasonal control would be the suppression of seasonal differences in foaming attributes by concentrating the milk to a relatively high viscosity. The viscosity then becomes the dominant factor in foaming characteristics. The concentrate can then apparently be controlled to give the required "boildown" during drying by adjustment of lecithin level as well as chamber pressure, gas content, feed temperature and other process variables.

A revised cost estimate indicates that vacuum foam-dried milk can be sold out of the dairy cabinet at supermarkets for slightly less than 20¢ per equivalent quart, which is almost 6¢ less than milk sold in large cities in two-quart paper containers.

2. Cheese. Making low-fat cheese on the pilot plant scale is progressing satisfactorily. The flavor of low-fat cheese can be improved by pretreating, for example, with lipase the small amount of milk fat that is used. Progress has been made in making a processed low-fat cheese from a blend of natural low-fat cheeses. The preliminary results provide a product with good flavor and slicing properties. The Economic Research Service has begun a marketing research program on natural low-fat cheese.

Considerable commercial interest has been shown in this new type of low-fat cheese. More than 50 cheese manufacturers have requested information, and upon request, samples have been provided to four leading cheese manufacturers.

Research under a PL-480 grant to the National Dairy Research Institute, Karnal, Punjab, India, indicates that rennet produced from bacterial sources makes Cheddar cheese comparable to that made by using commercial animal rennet. The protein degradation of the cheeses over a ten-month period was the same for both rennets. It was observed that frequent transfers of the bacterial isolates on milk agar produced progressive decrease in their ability to produce enzymes in the broth cultures. These cultures, however, retained their level of enzyme activity when preserved in soil up to a period of about 15 months. The ultraviolet irradiation of a bacterial strain resulted in higher enzyme production.

Research supported by a PL-480 grant at the Kaira District Cooperative Milk Producers Union, Ltd., (Anand, India) is making satisfactory progress in developing a cheese from buffalo milk standardized with low heat non-fat dry milk. Improvements in the cheese-making procedure have resulted in a great improvement in the product. Samples of the processed cheese made under the project had good body and texture. The flavor was clean and mild. All were superior to the samples submitted a year earlier.

Technologists at the College of Agriculture, Olsztyn, Poland, working under a PL-480 grant, continue to acquire information on the chemical changes during cheese ripening. The composition of ripening Tilsit cheese was studied and a number of components isolated and identified. Studies on the fermentative activity of some strains of lactic acid bacteria from the genera Streptococcus and Lactobacillus showed differences in the rates of lactose, glucose and galactose fermentation.

Research under a PL-480 grant to the Institute of Dairy Industry, Warsaw, Poland, found that some of the 45 mutants of Penicillium candidum possess greater proteolytic activity and/or greater vitamin B synthesis than the parent strain. Likewise, many mutants of Penicillium roqueforti had greater lipolytic ability than the parent strains and one had much

greater vitamin synthesizing ability. Thus, certain mutant strains should be much more desirable for use in the manufacture of Camembert and Roquefort cheeses.

3. Liquid sterile and concentrated milk. The addition of polyphosphates to sterile milk concentrates, to prevent gelation and sedimentation, has been commercialized in the production of both evaporated and single-strength sterile milk. It was the discovery that polyphosphates have this stabilizing action that makes possible the production of high-temperature short-time sterile milks.

Four-to-one sterile concentrates were prepared, with excellent resistance to gelation; the concentrates remained fluid for several years at 70°F.

Severe agitation during heat treatment, especially near the point of heat coagulation, accelerates coagulation and causes sedimentation during storage, an objectionable defect. When, however, milk concentrates are sterilized under static conditions, as in "in-can" processing, polyphosphates effectively retard coagulation and gelation, even in concentrates which have undergone drastic heat treatment. This finding suggests the possibility of employing ultrahigh-short sterilization schedules.

4. Milk fat. Anhydrous milk fat of very high quality was made in a continuous operation. It contains less than 0.1% water and maintains good flavor during storage at 40°F. for several months. Several lots of ghee have been made under a wide variety of experimental conditions. The flavor of the product depends upon the quality of the cream or butter used and the temperature and duration of heating. The liquid fraction of the product has much more flavor than the solid fraction. The studies on anhydrous milk fat and ghee suggest that fractionated milk fat may provide a source of flavor in other food products.

Attempts to prepare large capsules (1000-1500 microns) containing milk fat within an edible membrane were not successful.

5. Removal of radionuclides from milk. Under the research contract with Producers Creamery Company, Springfield, Missouri, it has been shown that 90-95% of present environmental levels of strontium-90 can be removed from skim and whole milk without appreciably changing the flavor of the pasteurized product. In this research, jointly supported by the Department and the U. S. Public Health Service, the fixed-bed ion exchange system showed that the process is economically feasible for use on a commercial scale. Changes in milk composition are minor. The cost per quart of milk is less than two cents, depending on the quality of the chemicals used and the rate of processing. The greatest factor in the processing costs is the cost of regenerant. It has thus been shown that if it should prove to be necessary it is practicable and feasible to remove radioactive strontium from fluid milk on a

commercial scale.

A U. S. Public Health Service contract with the Producers Creamery Company, Springfield, Missouri, has as its objective the determination of the feasibility and practicality of a combined anion and cation fixed-bed system for removing both strontium-90 and iodine-131 in a continuous process. The design of the equipment for this purpose has been approved.

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MEAT UTILIZATION - FOOD

Eastern Utilization Research and Development Division, ARS

Problem. Livestock production is our greatest single source of farm income. For the past several years over 30 percent of cash receipts from farming were derived from livestock sales. Likewise, the major portion of our land is used to grow livestock feed and forage. Hence, any research which succeeds in stimulating an increase in the consumption of meat and livestock products will have a profound effect on agriculture as a whole. For example, it is estimated that a one percent increase in meat consumption would require an increase in feed equivalent to 80 million bushels of corn.

The processing of meat and meat products also has an important effect on rural industry and rural employment. About half of our meat supply is derived from packing plants in rural areas. Many of these are small (the state of Pennsylvania alone has over 2,000 registered slaughterers) and cannot hope to maintain their own research facilities. They employ local labor, and their products are transported and sold by local truckers and business men. Thus, increases in meat consumption and improvements in meat technology will contribute to increased rural prosperity.

Increases in livestock consumption may be achieved through development of new or improved meat products, or through improved meat processing technology which results in lower costs. In addition, increases in the value of hides, animal fats, and renderers' proteins will benefit the livestock industry by providing additional revenues which could permit reduction in meat prices (thus stimulating consumption) or which could flow back through the marketing channels in whole or in part to livestock growers and feed producers. For example, it is estimated that loss of the market for hides would cause an increase of meat prices that would result in a decrease of 2 percent in meat consumption. Such a decrease would eliminate a market for feed equivalent to 160 million bushels of corn. Conversely, an increase in hide values would operate in the opposite direction and would result in greater income to the livestock industry and in increased utilization of feed grains.

Increased livestock consumption required both basic and applied research. Applied research is the forerunner of commercial practice and is an indispensable element in successful development. But applied research depends on new knowledge which must be developed in fundamental studies. Our supply of fundamental knowledge must be maintained and expanded if applied research is to be effective and fruitful. This need for basic research has been pointed out by the Animal and Animal Products Research Advisory Committee, by the Utilization Research and Development Advisory Committee, by the National Agricultural Research Advisory Committee, and by other responsible meat industry groups.

For the reasons given above, research which succeeds in increasing meat consumption can have a powerful effect on American agriculture. The potential effect may be assessed from the facts that meat has a high elasticity demand

(a 1-percent drop in retail prices will result in a 0.7-percent increase in consumption); the production of one pound of livestock requires the equivalent of 7 to 8 pounds of feed grains; and the present United States consumption of meat (174 lb/person in 1964) is still below that of Australia (234 lb.), New Zealand (222 lb.), or Uruguay (234 lb.). Economists predict that the 1965 United States consumption will be lower than in 1964.

Attaining increased meat consumption and providing new technological information for small processors will require a vigorous and balanced research program. There is need for more applied research on processing and preservation, including expanded studies on increasing the efficiency of sausage production and on new dried or semi-dried and ready-to-eat products. Of even greater importance is the need for more basic research on the physical, chemical, and microbiological properties of meat to provide a fund of knowledge for future technological improvements.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program involving chemists, biochemists, microbiologists, and food technologists engaged in both basic studies and in the application of known principles to the solution of problems in the processing of meat and meat products. The Department's research facilities are located at Beltsville, Maryland, and at Wyndmoor, Pennsylvania.

The Federal scientific effort devoted to research in this area totals 23.9 scientist man-years including 4.9 scientist man-years of contract and grant research. This effort is applied as follows:

(a) Research on chemical composition and physical properties involves 2.4 scientist man-years at Wyndmoor. A research contract at Louisiana State University provides for 1.0 scientist man-year to study the modification of muscle connective tissue constituents and their relationship to tenderness.

(b) Flavor research is conducted at Wyndmoor, and involves 4.4 scientist man-years. Additional research under a PL-480 grant is in progress at Gdansk, Poland, on antioxidant components of wood smoke used in meat-curing (5 years, 1963-1968).

(c) Research on color, texture and other quality factors involves 4.4 scientist man-years on investigations related to oxidation of tissue lipids at Beltsville, Maryland, and on fundamental studies of muscle pigment chemistry at Wyndmoor, Pennsylvania. The relationship between heme pigments and oxidative rancidity in cooked and frozen meats is being studied at Florida State University under a grant involving 0.7 scientist man-years.

Another grant, for research on the noncarbonyl compounds associated with rancid meat, involves 0.5 scientist man-years effort at Rutgers University. Additional research is in progress under a PL-480 grant at British Food Manufacturing Industries Research Association, Leatherhead, Surrey, England, on specific reducing systems in pork muscle (5 years, 1964-1969).

(d) Research on microbiology and toxicology of meat and meat products involves 5.4 scientist man-years at Beltsville, Maryland. In addition, contract research at Iowa State University, involving 1.1 scientist man-years, is concerned with a study of the fungi associated with cured meat.

(e) Technology - process and product development involves 2.4 scientist man-years at Wyndmoor, Pennsylvania. A research contract at Michigan State University involving 0.9 scientist man-years is for the purpose of developing new smoked meat products. Another contract provides 0.7 scientist man-years effort for research at the University of Missouri to develop new meat products for freezing. The development of new ready-to-eat meat products suitable for production in small, rural industries will be investigated under a contract at Southern University, Baton Rouge, Louisiana, and the reactions of muscle proteins as they relate to the thermal effects of meat processing and large-scale institutional cookery will be studied under a contract with Cornell University, Ithaca, New York. In addition, research sponsored by the Department under PL-480 grants is in progress at the following foreign institutions:

1. Taiwan Provincial Chung Hsing University, Taichung, Taiwan, on preparation of new semi-dehydrated type of fried meat products (3 years, 1964-1967).
2. University of Helsinki, Helsinki, Finland, on influence of fats on flavor and aroma of dried sausage (5 years, 1963-1968).
3. Central Institute for Nutrition and Food Research, T.N.O. Utrecht, Netherlands, on the use of protozoa to detect harmful substances in meat (5 years, 1965-1970).

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 51 scientist man-years is devoted to this area of research.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties.

Differences have been observed in the stability of the enzymatic activity of pig myosin as compared to beef myosin. This is the first clear evidence obtained on the difference between species. Pig myosin with increased activity has been prepared in good yield from pig longissimus dorsi. The ultracentrifuge patterns of myosin from pig and from rabbit were similar in appearance.

In contract research at Louisiana State University, the effect of environmental conditions after slaughter has been determined on tenderness, muscle contraction and glycolysis. The state of contraction of muscle after aging is significantly related to tenderness; tenderness appears to increase with muscle relaxation during aging. No relation was found between mast cell count and tenderness.

B. Flavor.

The water-soluble extract of ground, raw meat was dialyzed and four fractions were obtained. Most of the precursors of meat flavor were contained in one of the fractions. In this fraction, twenty-two amino acids have been definitely identified and four more tentatively identified. This fraction also contains five sugars and sugar esters, lactic acid, and inosinic acid and its degradation products.

Identification of the components of wood smoke condensates was continued. During storage of the condensate, methylvinylketone disappears and methylformate and methyl acetate are formed with concomitant decrease in methanol and acetic acid.

In research under a PL-480 grant at the Technical University, Gdansk, Poland, four fractions of curing smoke isolated by standard extraction methods have been investigated for their antioxidative activity using lard as the substrate. With the exception of formic acid, none of the compounds containing only carboxyl, carbonyl and neutral groups showed any antioxidative activity, but substances possessing both a phenolic and a carbonyl or carboxyl group showed a specific antioxidative activity to this substrate.

C. Color, Texture and Other Quality Factors.

1. Rancidity. Study of the development of rancidity in fats showed that 0.03% sodium nitrite had a greater pro-oxidant effect on back fat from hogs than 4% sodium chloride, that randomized lard was more stable than its parent lard, and that a wide variation of the keto-glyceride content of back fat occurred from different lines of fat- and meat-type hogs. Crystalline Girard T hydrazones of the various monocarbonyl classes have been prepared and their properties determined for the first time.

In grant research at Rutgers University, freezer-storage studies have started on the determination of the non-carbonyl volatile components formed in raw, freeze-dried and cooked beef muscle to evaluate the nature and significance of these components as associated with rancidity in meats.

2. Meat pigments. A study of the reaction between the heme pigment of meat, nitrite or nitric oxide and several reductants shows that wide variety of reductants are capable of reducing nitrite to nitric oxide. The results indicate that the overall reaction occurs in two steps, the reduction of nitrous acid to nitric oxide and then the reduction of nitrosylmetmyoglobin.

Research under a grant to Florida State University shows that the main enzymatic pathway for reduction of metmyoglobin and oxygen to be from lactate via lactate dehydrogenase, DPN, flavoprotein and the electron transport chain. The enzymatic reduction of metmyoglobin takes place only after oxygen has been practically exhausted from the tissues. Frozen cured meats kept well with a combination of ascorbate and polyphosphate as long as ascorbate remained present. The disappearance of ascorbate heralded the

onset of rancidity.

Results of research under a PL-480 grant at the British Food Manufacturers Research Association, Leatherhead, Surrey, England, indicate that the rate of color development in curing is dependent entirely on the changes brought about by natural mechanism remaining in the meat. It has been established that muscle enzymes systems in the presence of suitable substrates are able to effect an anaerobic transfer of the nitrosyl group from nitrosylferricytochrome c to metmyoglobin, the form in which the muscle myoglobin is present as a result of oxidation by nitrite. Nitrosylmetmyoglobin, a product of the transference, is readily reduced enzymatically to the comparatively stable desired pigment, nitrosylmyoglobin, a complex of the muscle pigment myoglobin with nitric oxide which is responsible for the characteristic color of the cured product.

D. Microbiology and Toxicology.

1. Microbial lipases. The two fractions of lipase from Pseudomonas fragi are two forms of the same enzyme. This enzyme requires a water-fat interface, and has no activity on any nontriglyceride molecule. The culture filtrate from Staphylococcus aureus is able to attack both the 1- and 2-positions of triglycerides, suggesting that it may contain two lipases, one of which selectively attaches the 2-position. A technique for screening for 2-position activity has been developed using cocoa butter as a substrate, and will facilitate screening cultures for this type of activity. Selective lipase activity will be of considerable use in studying the structure of triglycerides in fats.

2. Flavor improvement in cured meats. Progress has been made in studying the effect of curing agents and temperature on toxin production by strains Staphylococcus aureus. Enterotoxin B is detectable at 6 hours and reaches maximum production at about 36 hours. The toxin is stable and will pass through a membrane filter without loss of titer. Sodium chloride and sodium nitrate reduced the growth rate of Staphylococcus aureus, but sodium nitrite had little or no effect.

Contract research at Iowa State University shows that Penicillium and Aspergillus are the predominant genera from country-cured ham, while Penicillium and Scopulariopsis are predominant on "fermented" sausages. Inoculated hams showed much heavier mold growth after six months than uninoculated controls and better texture and appearance. Organoleptic evaluation slightly favored the inoculated hams. The latter had a higher free fatty acid and a lower carbonyl content than uninoculated hams at 4 months. At six and ten months of curing the free fatty acid content of uninoculated and inoculated hams were similar whereas the carbonyl content of the uninoculated hams remained higher. The discovery of the lower carbonyl content of inoculated meats may be important in establishing flavor factors in cured meat.

E. Technology - Process and Product Development.

1. Processing research. A study of color development during the manufacture of frankfurter and bologna shows that emulsions prepared in an atmosphere of air developed color after an initial lag. When an atmosphere of nitrogen was used there was no lag. The lag was also reduced by vacuum and by the use of additives, ascorbic acid and cysteine. This lag apparently affects the time required for meat to consume the oxygen absorbed during comminution.

The heat coagulation of the relatively heat-resistant proteins in pork has been shown to be significantly affected by rate of heating in addition to final temperature. Rapid heating coagulated more protein than slower rates at the same internal meat temperature. Protein extracts of heated cured hams were fractionated into five major components, one of which was identified as acid phosphatase. Since measurement of the acid phosphatase content has been suggested as a measure of the thermal history of meat products, these investigations may furnish a basis for such an index.

Research under a PL-480 grant at the University of Helsinki has shown that the addition of Micrococci and Lactobacilli in the preparation of dry sausage have a distinct influence upon changes occurring during the ripening period. Lactobacilli produce a decrease in pH and speed up the ripening process, but frequently impart off-flavors and color defects. Micrococci do not accelerate ripening, but appear to prevent the adverse side effects of Lactobacilli. Both cause a decrease in count of undesirable bacteria during the ripening period. In pilot plant experiments, simultaneous addition of Lactobacilli and Micrococci reduce the ripening period from 19 to 6-7 days and weight loss was only 7% on an average as compared to a typical 20% weight loss.

2. New products. In contract research at Michigan State University to develop improved smoked meat products additional information was obtained on the effect of humidity in smoking fresh meats and sausages. It was also found that the smoke permeability of artificial casings of different types, and those obtained from different sources, may differ as much as three or four-fold. Analysis for carbonyl shows promise as a means of measuring the smoke penetration.

Research on preparation and storage of precooked frozen beef products continues under a contract at the University of Missouri. Chemical studies of stability during frozen storage showed that quick thawing at 104°F. resulted in losses of nucleotides. The constituents with the greatest potential as indices of quality are inosinic acid, creatine, creatinine and total extractable nitrogen.

In preparation of a fried meat product at Chung Hsing University, Taiwan, under a PL-480 grant, meat pieces are deep-fat fried after one or more preliminary steps such as enzyme (papain) action, salting or seasoning, and coating with egg albumin. Results indicate that pieces of about 1" x 1" x 1/2" fried to a moisture content of 30-40% (minimum internal temperature of 65°C.) were most acceptable. Dipping the pieces of meat in egg albumin prior

to frying improved both the texture and flavor of the product.

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ANIMAL FATS AND OILS - INDUSTRIAL PRODUCTS
Eastern Utilization Research and Development Division, ARS

Problem. The 4-1/2 billion-pound-per-year output of inedible fats is one of the major products of the livestock industry. It also is one of major concern, because while production of animal fats has more than doubled in the last 15 years, its principal outlet (in soap) has declined sharply, and is still declining.

The best answer to the question of what to do with huge amounts of fats is to find new uses through utilization research. Already utilization research has played a leading role in finding new uses for over 1 billion pounds of animal fats, and thus helped retain markets for fats. Use of fat in animal feed which was developed through research, has now become the number one domestic use of inedible fats. There is need, however, for new uses not merely to retain or defend markets, but to expand them, and to upgrade the value of animal fats. The organic chemical industry presents a good opportunity for expanded markets, producing as it does a multitude of products--polymers, plasticizers, insecticides, herbicides, lubricants, paper chemicals--totaling 10 billion pounds. Animal fats possess "built-in" properties which make them potentially useful as raw materials to the chemical industry, but research must be done to realize this potential.

An increase of 1 cent per pound in the value of inedible animal fats would provide an additional revenue of \$40 million of the livestock industry. This additional revenue will help the industry and growers in the same way as revenue from other animal products and by-products.

The attainment of an increase in the monetary returns from livestock requires both applied and basic research. Applied research is the forerunner of commercial practice and is an indispensable element in successful development. But applied research is based on the foundation of fundamental knowledge that is acquired through basic research, and represents the exploitation of this fundamental knowledge. The supply of fundamental facts about animal fats; composition, methods of separation of constituents, preparation of chemical derivatives of constituents and determination of their physical and chemical properties must be maintained and expanded if applied research is to be most effective and fruitful. The need for basic research has been pointed out by the Commission on Increased Industrial Use of Agricultural Products, the National Agricultural Research Advisory Committee and by other responsible groups.

USDA AND COOPERATIVE PROGRAM

The Department has a broad program of basic and applied research at Wyndmoor, Pennsylvania, and at additional locations where contract and grant research is being carried out involving chemistry and physics, aimed at developing new and improved products from fats for use in industry. The total Federal

scientific effort devoted to this program is 39.9 scientist man-years, of which 4.3 are contract and grant research.

The research devoted to studies on chemical composition, physical properties and structure of animal fat amounts to 12.3 scientist man-years, of which 9.9 is at Wyndmoor. This research includes studies of composition of animal fats, the separation of constituents, the preparation of derivatives, the determination of physical and chemical properties of pure compounds and derivatives and, where applicable, computer programming of mathematical methods to expedite evaluation and interpretation of experimental data. A research contract on the chemical and physical characteristics of organic peroxides involving 0.3 scientist man-years at the University of Pittsburgh, Pittsburgh, Pennsylvania, has been completed. Research at Villanova University, Villanova, Pennsylvania, is continuing under a contract to study special interrelationships within triglyceride molecules and a contract on the X-ray investigation of triglycerides, each involving 0.5 scientist man-years. A research grant involving 0.7 scientist man-years at Storrs, Connecticut, provides for the synthesis of pure glycerides. At Lehigh University, Bethlehem, Pennsylvania, the interfacial absorption characteristics of fatty acids is being studied under a research contract involving 0.4 scientist man-years. Research sponsored by the Department under a PL-480 grant (5-years, 1966-1971) was initiated at Technical University, Gdansk, Poland, to study the thermally stable stationary phases for gas-liquid chromatography.

Research on chemical and physical investigations to improve products involves 25.7 scientist man-years at Wyndmoor and 1.9 in contracts and grants, a total of 27.6 scientist man-years.

Studies related to polymers and plastics include the synthesis of organic compounds and the preparation and evaluation of products derived from animal fat. The contract research at the University of Arizona, Tucson, on plastics and plasticizers has been completed. In the contract research (now completed) with U. S. Industrial Chemical Company, New York, on ethylene copolymerization with unsaturated fatty acids and gum naval stores, EU shared the effort to the extent of 0.3 scientist man-years in cooperation with SU.

Compounds derived from animal fats are used as starting material for the preparation of lubricants and lubricant additives. This research is conducted at Wyndmoor.

Research on development of improved synthetic detergents based on animal fats includes preparation, testing of detergent power, and measurement of biodegradability of α -sulfo fatty acids and their esters, tallow alcohol sulfates and other fat derived materials. The high pressure hydrolysis of animal fats to alcohols without simultaneous chain saturation is being investigated at Swift and Company, Chicago, Illinois, under a research contract involving 1.1 scientist man-years.

Exploratory investigations, employing novel and/or improved reaction techniques are conducted at Wyndmoor to provide new chemical derivatives from animal fats. A research grant with the Hormel Institute of the University of Minnesota at Austin, Minnesota, involving 0.5 scientist man-years provides for the investigation of the ozonization of animal fats.

In addition, research sponsored by the Department under PL-480 grants is in progress at the following foreign institutions:

1. Technical University, Gdansk, Poland, on kinetics and thermodynamics of fat autoxidation (5 years, 1964-1969).
2. "L. Torres Quevedo" Scientific Instruments Institute of the "Juan de la Cierva" Foundation for Applied Research, Madrid, Spain, on cocoa butter substitutes from animal fats (5 years, 1962-1967).
3. University of Bombay, Bombay, India, on the preparation and properties of long chain sulfated monoglycerides (5 years, 1964-1969).
4. Universite d'Aix-Marseille, Marseille, France, on hydroxylated fatty derivatives (5 years, 1962-1967).
5. Institut des Corps Gras, Paris, France. on autoxidation of fat at low temperatures (3 years, 1965-1968).
6. Centre National de la Recherche Scientifique, Paris, France, on polyhalogenated fatty acids and their derivatives (2 1/2 years, 1966-1968).
7. Technical University, Gdansk, Poland, on thermally stable stationary phases for gas-liquid chromatography (5 years, 1966-1971).

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 3.1 scientist man-years is devoted to this area of research.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition, Physical Properties and Structure.

Selected tissues (back fat, leaf fat, liver, pancreas and serum) from two breeds of pigs, Duroc and York, were examined for differences in fatty acid and/or glyceride composition. Animals were chosen on the basis of high and low percentage of back fat. Thus far there appears little difference between breeds or between level of back fat. The composition of the serum lipids resembles that of the liver in that most of the C-16 acids are found in the 1-3 position of the glyceride.

A new procedure has been devised for the quantitative preparation of the methyl esters of long-and short-chain acids for gas-liquid chromatographic analysis. The pancreatic lipase hydrolysis technique has been modified to permit satisfactory operation for high-melting triglycerides.

In contract research at Villanova University a computer program was applied to a study of the interactions between parts of triglyceride molecules which come close to each other. Fundamental information has been obtained on the internal rotation barriers of the hydrocarbon parts of these molecules.

Under another contract for research at Villanova, 9 triglycerides have been prepared. The structure of one of them (β -11-bromoundecanoyl- α,α' dicaprin) has been determined, and represents the first instance where the structure of a mixed triglyceride has been determined.

Research on the synthesis of pure glycerides continues under a grant at the University of Connecticut (Storrs). Alpha-monoglycerides were prepared easily, as were also the 1,3-diglycerides of palmitic and stearic acids. Preparing the 1,2-diglycerides was more difficult. Two pure triglycerides, 2-oleo dipalmitin and 1-stearo diolein, were synthesized and furnished to EU where they will be investigated to establish their physical and rheological properties.

Single crystal X-ray examinations were made on dibenzoyl peroxide (an example of the diacyl peroxide class) and two peroxy acids. These studies have helped clarify some of the structural features of the two classes of peroxide compounds. This research, under a contract at the University of Pittsburgh, has been completed.

Experimental methods have been developed for obtaining spectra of fat components in the crystalline state; practically all components of fat can thus be positively identified and characterized. Polarized infrared spectroscopy was developed and its use in conjunction with X-ray powder diffraction measurements provide a good way to investigate the chemical and physical structure of fats and their derivatives.

In contract research at Lehigh University examination was continued of the series of esters of α -sulfo fatty acids representing those of the detergent type and those of the wetting agent type. The methodology involved in measuring surface tension and contact angles has been improved and is now satisfactory. Detergent types of the esters of α -sulfo fatty acids tend to show a decrease in surface tension with time, whereas most wetting agent types show no change. Cross-sectional molecular areas were determined and two types show a difference in cross-sectional area.

The normal alkyl esters of long chain acids can be distinguished by X-ray diffraction measurements. Other modern techniques are being used for fundamental studies of the properties of animal fats and derivatives. Progress has been made in applying dielectric measurements to the structural

investigation of these materials. A capillary extrusion rheometer was developed for study of the flow behavior of lard. Research was continued on the research of polyunsaturated fatty acids with specific cis-trans and positional isomerism.

The development of mathematical methods employing a computer for treating experimental data from basic research continued with the development of a computer program for the dielectric constant and dielectric loss of some fatty acid esters. Also, a program was developed for investigating the possibility of hydrogen bonding between hydroxyl groups and olefinic double bonds. Likewise, work was continued on the theoretical treatment of counter-current distribution.

B. Chemical and Physical Investigations to Improve Products.

1. Plastics investigations. A series of rigid urethane foams were prepared from oxypropylated 9,10-dihydroxystearic acid. The physical properties of these urethane foams were similar to those of commercial products. Urethane foams containing fire-retardants have also been prepared and are being evaluated.

In studies related to the preparation of polymers from animal fat derivatives, data were obtained suggesting that many monomers with C-18 side chains will be efficient as internal plasticizers. Since fat-derived allylamide and allyl ester monomers can be easily prepared directly from tallow or tallow acids, N-allylstearamide was copolymerized with three commercial comonomers. Copolymers of vinylidene chloride and five acrylamides were prepared and their solution properties were determined.

Contract research at the University of Arizona, now completed, showed that vinyl stearate continues to be a promising internal plasticizer for vinyl chloride.

2. Detergents investigations. Alkyl palmitates and stearates can be alpha-sulphonated directly with liquid SO_3 in a yield of 75%. This direct sulphonation has economic advantage because it avoids the use of solvent and the need to isolate the α -sulfo acid. Combinations of saturated or unsaturated tallow alcohol sulfates with esters of α -sulfo tallow acids are synergistic with excellent solubility, foaming and detergent properties. These fat-based detergents are also readily biodegradable.

Investigation of ether alcohol sulfates was continued. The products derived from saturated tallow alcohols and propylene oxide or 1,2-butylene oxide have good calcium ion stability and lime soap dispursing power.

An analytical method for determination of sulfate ions in detergent media was devised to follow the metabolism of anionic sulfate and sulfonate detergents in their biodegradation by microorganisims.

In PL-480 supported research at the University of Bombay, a convenient method has been developed for the preparation of pure α -monoglycerides. Five long-chain (C_{12} to C_{18}) sulfated monoglycerides have been prepared.

The high pressure hydrogenolysis of animal fat to alcohols without simultaneous chain saturation is being investigated under contract research at Swift and Company. Washing experiments on tallow alcohol sulfates of known composition show that unsaturation improves detergency in cold, hard water.

3. Lubricant investigations. The alkyl and glyceryl ester of polyunsaturated acids react almost quantitatively with alkyl phosphonates to give viscous, oily products. The phosphorous-containing materials are effective hydrodynamic lubricants as base oils and also as additives to refined paraffin crude oils of synthetic oils. The evaluation of these lubricants indicate that they are superior to some commercial materials.

Several α -branched fatty acid esters were synthesized and showed considerable potential for use as specialized lubricants. Larger quantities of pure branched chain esters of fatty acids were prepared for lubricant study and evaluation.

4. Reactions investigations. The periodic acid cleavage of epoxy esters permits the direct conversion of epoxides to aldehydes and permits the determination of the location of epoxy groups on hydrocarbon chains.

The cyanoethylation of hydroxylated fatty esters and related compounds has been achieved and provides 95% yields of β -cyanoethyl ether derivatives.

The reactions of isopropenyl stearate are affected by the reaction medium. A catalyzed reaction in the absence of solvent or diluent produces stearone. In the presence of a high boiling ester, a rearrangement reaction of the isopropenyl stearate forms the potentially useful β -diketone, heneicosane-2, 4-dione. With inert hydrocarbons the product is hexadecyl ketene (stearo-ketene). On standing, the ketene dimerized to form 2,4-dihexadecylcyclobutyl-1,3-dione.

In grant research at the Hormel Institute the ozonization of saturated fat materials has resulted in the formation of light hydrocarbon gases and dimers, trimers and polymers of the starting material. Pyrolysis of ozonides of unsaturated material in the presence of metals in the reduced state produces aldehydes.

Investigation of the autoxidation of emulsified fats shows that anionic emulsifiers enhance the pro-oxidative action of metal ions and basic amino acids to act anti-oxidatively. The experiments indicate that the necessary condition for the pro-oxidative interaction of metal ions (Fe,Cu) with a basic amino acid such as histidine, lysine and arginine is the formation of a partially complexed metal ion.

The kinetics and thermodynamics of fat autoxidation is being studied under PL-480 supported research at Technical University, Gdansk, Poland. The experimental and analytical techniques, particularly polarographic peroxide values applied to metal oleate autoxidation has provided useful data. The data for double bond disappearance indicates that this is a first order reaction.

In PL-480 supported research as Universite d'Aix-Marseille, Marseille, France, progress continued on the preparation of hydroxylated derivatives of fatty acid. In a catalyzed reaction, oleic acid was converted to allylic monohydroxy unsaturated acids plus some by-products.

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HIDES AND LEATHER UTILIZATION
Eastern Utilization Research and Development Division, ARS

Problem. To maintain the utilization of animal hides and skins at a profitable level there is need to find new products and processes to provide outlets for about 13 million cattlehides that are now available in excess of domestic needs. The foreign markets that currently absorb these surplus hides are also threatened by the increased hide production and decreased per capita use of leather (the principal outlet for hides) that have dislocated U.S. markets and caused prices to drop so precipitously in the last 10 years. To meet this problem there is need for upgrading the quality of raw hides and skins, for reducing the costs of producing leather, and for developing new and non-conventional products from collagen. To achieve these objectives research is needed to develop improved curing processes and agents, more effective control measures for (ante mortem) defects such as grubs, brands and parasite damage, and improved methods of take-off. Fundamental research is needed on the composition of hides to provide basic information on the chemical, physical and physical-chemical properties and reactions of collagen and other hide components for use in studies on chemical modification and on the development of new and improved products and processes. Development of new, more rapid and economic processes for curing, handling, unhairing and tanning hides is needed to reduce the cost of producing leather. There is also need for research on the chemical modification of hide proteins to develop leather products with such improved "built-in" properties as increased resistance to wear, scuffing and deterioration from perspiration, enhanced washability, dry-cleanability and improved dyeability. There is also need for research on the physical and chemical properties of collagen to obtain information for use in dispersing and regenerating the fibrous structure without degrading its unique properties for developing nonconventional products that will provide new outlets and markets for hide proteins, with special reference to the field of edible products.

USDA AND COOPERATIVE PROGRAM

The Department is conducting a broad program of basic and applied research on hides, skins and leather at Wyndmoor, Pennsylvania, and at additional locations where contract and grant research is being carried out; this involves physicists, chemists, biochemists, microbiologists and leather technologists.

The Federal scientific effort devoted to the over-all program totals 27.2 scientist man-years, as follows:

(a) Research on chemical composition, physical properties and structure of hides and leather involves 12.5 scientist man-years at Wyndmoor. One line of investigations is concerned with the isolation of collagen and other hide components and basic research on the chemistry of collagen. This research is supplemented by a grant at Northwestern University School of Medicine, Chicago, involving 0.6 scientist man-year to study physical properties of collagen and a PL-480 grant at the University of Turku, Finland, (5 years,

1960-1965), on fractionation of gelatin and collagen. Research is continuing at the University of Turku under a PL-480 grant (3 years, 1965-1968) for basic investigations on the structure, biosynthesis and maturation of collagen.

Other investigations at Wyndmoor are concerned with the relation of hide composition and structure to leather properties. Additional research is in progress at the Central Leather Research Institute, Madras, India, under PL-480 grants on (a) the hydrothermal shrinkage of collagen and leather, (3 years, 1964-1967) and (b) comfort properties of shoe leather (5 years, 1964-1969).

(b) Chemical and physical investigations to improve products involves 6.6 scientist man-years at Wyndmoor. This research is concerned primarily with the investigation of chemical modifications of hides prior to and during tanning operations to provide improved leather. A contract at the University of Cincinnati, Cincinnati, Ohio, provides 0.2 scientist man-year effort for research on the noncollagenous proteins of cattle hides. Midwest Research Institute, Kansas City, Missouri, is conducting contract research involving 0.5 scientist man-year to study the dispersion of collagen.

In addition, research sponsored by the Department under PL-480 grants is in progress at Central Leather Research Institute, Madras, India, on (a) polyphenolic tanning compounds (5 years, 1962-1967) and (b) preparation and determination of physico-chemical properties of polypeptidyl derivatives of collagen (5 years, 1966-1971), and at the British Leather Manufacturers Research Association, Surrey, England, to investigate chemically reactive compounds for improving leather stability (5 years, 1963-1968).

(c) Technology - process and products development involves 6.0 scientist man-years at Wyndmoor. Research includes development of new tanning processes for hides and skins to provide products of superior durability and development of regenerated collagen products. Contract research at the University of Cincinnati, Cincinnati, Ohio, involves 0.8 scientist man-year on the abnormalities of leather characterized by a depleted, mushy texture.

Additional research under PL-480 grants is in progress at: (1) Central Leather Research Institute, Madras, India, on (a) relation of hide quality to tanning rate (5 years, 1962-1967), (b) radioactive tracer study of mineral tanning (5 years, 1965-1970), and (c) rapid tannage of sole leather (5 years, 1965-1970); and (2) Leather Research Institute, T.N.O., Waalwijk, Holland, on kinetics of chrome tanning (4 years, 1964-1968).

PROGRAM OF STATE EXPERIMENT STATIONS

State stations reported no research in this area.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition, Physical Properties and Structure.

1. Protein constituents and collagen. Nuclear magnetic resonance studies were initiated to obtain information concerning the fundamental factors which determine the secondary structure of collagen. NMR spectra have been obtained for several amino acids. The studies show that the stable forms of phenylalanine are not those predicted by theory. Instead, the data suggests that a single conformation predominates in which the C-C-C-N dihedral angle is approximately 30° . Preliminary results with infrared studies suggests that the predominate features of the secondary structure of proteins can be satisfactorily determined in deuterium oxide solution.

When collagen is dissolved from calfskin by means of citrate buffer the concentration of collagen in the liquid phase increases and then levels off. Replacement of the buffer with fresh buffer dissolves still more collagen and this process may be repeated several times before the exhaustion point is reached. The solubilizing studies have resulted in obtaining larger yields of dissolved collagen from skins. The construction of automated equipment for solubilizing collagen has been completed. The proper conditions are maintained automatically through electrical conductivity and pH sensing elements. A water-soluble component with unusual properties has been isolated from solubilized collagen preparations. It has been found that pickled cattlehides have an extremely slow rate of equilibration with salt and acid.

In grant research at the Northwestern University School of Medicine, Chicago, additional information was obtained on the hydrogen bonding in the solvent pairs formic acid-dimethyl formamide and formic acid-N-methyl acetamide. Mutarotation studies on poly-L-proline, poly-L-hydroxyproline and poly-O-acetyl-L-hydroxyproline showed different kinetics for these materials.

In research under a PL-480 grant at the University of Turku, Finland, the optimal conditions for starch-gel electrophoresis of heat-denatured collagen were determined. The effect of long heat denaturation of collagen was studied and various subunits which resulted from this treatment were fractionated by electrophoresis. Degradation of collagen under alkaline conditions produced an unexpected subunit. Research under this grant has been completed and will be followed by another which provides for basic investigations on the structure, biosynthesis and naturation of collagen.

2. Hides and leather. Microscopical investigation of skin and leather fiber structure has revealed the structural features of two important leather defects. One, calfskin veininess, is caused by large void spaces of undetermined origin around the larger blood vessels of the grain surface. The other defect is abnormal vertical fiber structure, which leads to greatly reduced strength in resultant side leathers. Polarization microscopy was used in four different ways to study this vertical fibre defect in hides.

This technique permits more ready evaluation of the hides, and densitometry applied to the photographic films provides a quantitative expression of the degree of abnormality.

The transition of solubilized collagen from a helix to a random coil can now be measured quickly and with a small amount of sample by differential thermal analysis. The effect of moisture on the thermal and mechanical properties of leather was begun with investigations which utilized two techniques, stress relaxation and differential thermal analysis. Measurements were made of the relaxation ratio of a sample of vegetable tanned leather and of water binding by collagen in hides and leather. The effect of moisture on the thermal and mechanical properties of leather may serve as a good indication of the effect that tanning and other modifications have made in a hide.

Research in progress under a PL-480 grant at the Central Leather Research Institute, Madras, India has demonstrated that the physical changes that collagen undergoes when subjected to heat are more complicated than had been predicted. It was found that the effects of pretreatments and of cross-linking agents can not be explained by application of theories developed from studies of elastomeric polymers. It appears that studies of hydrothermal shrinkage will produce data highly significant to the elucidation of the physical properties of collagen and the behavior of leather.

The comfort properties of shoe leathers is being investigated under a PL-480 grant at the Central Leather Research Institute, Madras, India. Experimental studies have shown that leather can absorb an appreciable amount of perspiration and can give away the same in the process of evaporation, thus acting like a reservoir. The leather can also spread perspiration over its surface uniformly. Repeated flexing increases water vapor permeability and air permeability. Leathers with resin finishes have less permeability than leather with protein finishes. The relative humidity, present during actual use conditions, in various places between the foot and the shoe for a wide variety of shoes was above 65% at all places. The highest values were found in the region where the sole of the foot comes in contact with the shoe. A rubber sole, a hair-on upper or a canvas upper increased the relative humidity present within the shoe. The dissipation of perspiration and the increased permeability of leathers with use may be important properties specific for leather.

B. Chemical and Physical Investigations to Improve Products.

1. Mannich reaction. Studies on the Mannich reaction involving interaction between amine, formaldehyde and a compound with an active hydrogen indicated that malonic acid is a promising source of the active hydrogen. This reaction, which incorporates new carboxyl groups into the hide, is easy to carry out and improves fixation of chrome and alum. Research indicates that lysine participates in the reaction and that new amino acid residues are formed in the protein. The formaldehyde and malonic acid can be added together but, for best results, the treated hide must be tanned separately with chrome. The product has a high shrink temperature and has good

resistance to deterioration on washing.

2. Other chemical modifications. Experiments using reactive leather dyes demonstrated that these dyes appear to impart the property of wash fastness. This is in addition to perspiration resistance, which can be attained through glutaraldehyde tanning. Leather made by tanning with dimethylol urea plus resorcinol had excellent resistance to perspiration and is nearly white in color. A large-scale test of various types of sheep and goat skins provided good quality leather with a striking pebbled grain effect. This leather, however, has inadequate resistance to light, due to the resorcinol.

In research under a PL-480 grant with the British Leather Manufacturers Research Association, work has continued on the mode of action of aldehydes in stabilizing collagen. The use of combinations, such as formaldehyde-acrolein, glutaraldehyde-acrolein and glyoxal-dialdehyde starch revealed differences in reactivity, stability and the extent to which different protein groups are involved. Reaction of collagen with other compounds has been more difficult to achieve. Triazine derivatives, acyl chlorides, and isocyanates are insoluble and sensitive to water, and difficulties arise with diffusion through a solid fibrous material.

The encouraging results obtained with purified tannin derived from mangrove in research in progress under a PL-480 grant at the Central Leather Research Institute, Madras, India, has led to the fractionation and evaluation of other tannins. The source of phenolic tannins includes babul and dhawa. Dhawa was found to be a better material than babul for pretanning and re-tanning with chrome. The observation that purified babul extract has a fungicidal action is interesting since this is contrary to the usual experience.

3. Pretannage investigations. The application of an aqueous solution of a polar organic compound, such as butyl carbitol, to animal hides permits their dehydration to give sides which are white, fibrous, and flexible. A fresh calfskin dehydrated by this method was rehydrated in a lime-unhairing bath and chrome-tanned to give a product resembling normal chrome leather. In other experiments tanning agents were added during the dehydration step to provide leathers which were completely tanned, clear-grained and flexible. Because hides and skins are perishable, dehydration if it can be accomplished economically, becomes an attractive method for preserving and stabilizing them.

Research conducted under a contract at the University of Cincinnati showed that the extraction of noncollagenous proteins from cattle hides prior to tanning gave leathers with higher tensile and grain crack strength and a finer break than control hides. The optimum conditions (primarily number of extractions and concentration of salt in the brine) were determined, and 40 hides were processed under these conditions at the East St. Louis plant of Swift and Company. The hides have now been made into leather which is undergoing evaluation.

In contract research with the Midwest Research Institute at Kansas City, Missouri, experiments are in progress to develop simplified procedures for dispersing the collagen from lime-unhaired bellies without degrading its physical and chemical properties. The new USDA trim can make available sizeable amounts of collagen from the areas of hides least desirable for leather.

C. Technology - Process and Product Development.

1. Enzymic unhairing of hides and skins. Completed studies on the enzymic unhairing of hides have demonstrated that these hides can be converted into satisfactory sole leather of commercial quality. A few lines of shoe upper leather and a crushed type handbag leather can also be made from enzyme unhaired hides without modification of tannery procedures. When enzyme unhaired hides are subjected to a brief liming treatment, additional lines of chrome-tanned shoe upper leather can be obtained. However, results between tanneries were erratic. Tanning and post-tanning operations must be adjusted to the physical conditions of the unhaired stock.

2. Abnormalities of leather. Contract research with the Tanners' Council Research Laboratory at Cincinnati, Ohio, shows that the abnormal hide condition that produces weak, mushy leather occurs most frequently in the kidney area of heavy, plump Hereford hides. This is a raw stock defect which is not caused, or significantly alleviated, by processing into leather. It is due to a vertical fibre weave in the center portion of the hide. Sorting plump, heavy Hereford hides and diverting them into sole leather, where strength is less important, is the simplest commercial answer to the problem at present.

3. Glutaraldehyde tannage. Shearlings tanned with glutaraldehyde and basic chromium sulfate are in commercial production for use as hospital bed pads and as paint rollers. Hospital tests indicate that this tannage provides pads which are substantially more durable than alum- or chrome-tanned shearlings. This tannage has also replaced, in one firm, the tannage of shearlings with vegetable or bark tannins. Glutaraldehyde also improves the quality of work glove leather and book binding leather.

4. Regenerated collagen products. Equipment has been ordered for cutting and grinding hides and for dispersing the collagen for subsequent regeneration. Hides swollen with acids are easier to grind and the collagen easier to disperse than at a pH of 7.5-8.5. This was true for enzyme-unhaired and also for limed hides. Dispersions are being prepared from hide sections such as bellies, shoulders and splits in this attempt to find volume uses for collagen other than leather.

5. Chrome tanning. In the research under a PL-480 grant at the Lederinstitut T.N.O., Waalwijk, Holland, on the kinetics of chrome tanning, the influence of ratio of volume of tanning solution to weight of collagen on chrome retention was investigated. The effect of volume change varies with initial concentration of chrome; with chrome liquors of rather high concentration the rate of reaction and chrome fixation decreases with increasing volume ratio,

with fairly low initial concentration there is an increase of reaction velocity and chromium uptake with increasing volume ratio. The effect of basicity is more pronounced for the latter systems, especially with increasing volume ratios.

Research at Central Leather Research Institute, Madras, India, includes two other PL-480 projects. In the preliminary stages of work on radioactive tracer study of mineral tanning, methods have been established to determine ionic sulfate in chrome-tanning complexes by a scintillation technique.

Under the grant to study relationships of hide quality to tanning rate, the presence of hydroxyproline in the proteins extractable from hide pieces has been correlated with factors of deterioration such as hair slip, odor and inadequate salting. These studies show that collagen is a relatively resistant protein and that hides can be neglected for up to 20 hours before hydroxyproline becomes detectable in the extract. The noncollagenous proteins are much more susceptible to degradation as shown by a rapid rise in extractable nitrogen and tyrosine. In other studies on hides from fallen and slaughtered animals, a slightly acidic soak prior to longer liming seems to help in preventing subsequent staining of the leather due to occluded blood.

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WOOL AND MOHAIR UTILIZATION

Western Utilization Research and Development Division, ARS

Problem. Traditional markets for wool and mohair have been lost to synthetic fibers because consumers prefer garments that hold their pleats and creases, resist shrinkage and wrinkling during washing, and dry quickly. Natural wool and mohair outclass the synthetics in tailorability, comfort in wear, appearance, and hand, but lack certain features now being exploited by the promoters of synthetics. Furthermore, some current processing methods damage, distort, or weaken wool and mohair fibers and injure performance and appearance of the fabric. We need processes that will modify natural fibers to give a range of comfortable and attractive fabrics that resist deterioration in processing and wear. Fabrics must be durably resistant to wear, wrinkling, pilling, abrasion, yellowing, soiling, felting and relaxation shrinkage, acid and alkali weakening, insects, and microorganisms. New markets in industrial and other uses would develop for new types of fabrics, woven and non-woven, made from natural wools and from blends of wool with modified wools or other fibers. Wool could have a part of the new, rapidly developing market for stretch fabrics if we could practicably impart permanent stretch into wool yarn. Research toward such developments requires fundamental information on the chemical, physical, and structural nature of natural fibers and their modified products.

To sustain a stable sheep and wool industry in the United States, mills must be supplied with processing information on new and improved wool and mohair products. Synthetics have cut into wool markets because the synthetics are uniform in price and quality and because detailed processing information is available from producers.

USDA AND COOPERATIVE PROGRAM

The Western Utilization Research and Development Division conducts a broad basic and applied research program on wool and mohair to develop new and improved fibers and fabrics that can increase markets. Fundamental research seeks new facts on chemical and physical properties of natural fibers, and we use such knowledge to modify fibers and fabrics so that they will resist degradation by heat, light, chemicals, staining, abrasion, and insects; retain creases; shed wrinkles; and require little care. Department scientists bring research results to the industry through technical publications, public service patents, exhibits, news media and conferences.

The Federal program is conducted at the Division headquarters at Albany, California; by contract in Durham, North Carolina, and Washington D.C.; and by grant funds under P.L. 480 in India, West Germany, Sweden, England, and Finland.

The Federal program of research in this area totals 24.8 scientist man-years, including contract research equivalent to approximately 1.5 scientist man-years per year. Of this number 9.7 are assigned to chemical composition, physical properties and structure; 7.9 to chemical and physical investigations to improve products; and 7.2 to technology--process and product developments. In addition, the Division sponsors six research grants under Public Law 480.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 5 scientist man-years is devoted to this area of research.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition, Physical Properties and Structure

1. Measurement of Physical Properties. Research aimed at improving the properties of wool has relied heavily upon fundamental knowledge of structure, chemical properties and physical behavior. In studies of this nature, it was found that measurement of stress relaxation in wool fibers can be used to determine diffusion of water and certain other chemicals into wool. The measurement of diffusion coefficients until now has been difficult, but the development of this new stress-relaxation method greatly simplifies the procedure. It will have important applications in dyeing.

For the evaluation of fabric surface characteristics a new photographic method was developed. The method has been applied in making critical measurements of the surface fuzziness of treated and untreated fabrics under various conditions of wear.

Further research was carried out on methods of testing of physical properties of bundles of wool fibers and on correlation of physical measurements of abrasion resistance with actual wear tests. The correlation of results of accelerated tests with actual wear trials of fabrics is of importance for the speedy and practical development of chemically modified wool and mohair fabrics.

Problems related to crimp in wool fibers are being subjected to critical analysis under a P.L. 480 grant recently executed in Israel.

Physical measurements involving particularly ultrasonic absorptions are being applied to a study of molecular processes in model substances related to wool. This work is being carried out under a P.L. 480 grant to the University of Allahabad in India. Basic information on the internal structure of fine, coarse, and chemically modified wools is being developed through the application of low-angle X-ray diffraction techniques. This difficult research, which is being performed under a P.L. 480 grant at the German Wool Research Institute at Aachen, is providing insight into the structure of wool keratin and should lead to information concerning the

amino acid distribution along the fiber axis. Further understanding of the molecular structure of wool is being obtained through a P.L. 480 grant to the Karolinska Institutet in Stockholm, Sweden. Cross-sections of different levels of developing fiber cortex have been studied with electron microscopy which showed the location of formation of fibrils and filaments and presented evidence of the aggregation of the filaments into twisted cables.

2. Study of Chemical Composition. The physical separation of wool fiber into protein fractions has been followed by chemical analysis of the components. Significant differences were found in the amino acid composition of the protein fractions. These studies are aimed at increasing our understanding of the wool protein structure and its relationship to properties observed in processing and use.

A study of the chemical structure of wool protein in the neighborhood of the cystine residues is being carried out at the Wool Industries Research Association in Leeds, England, under a P.L. 480 grant. The way the amino acid units are arranged in the protein in the vicinity of the cystine residues must be the most important reason why some of the cystines are more reactive than others. Properly manipulated, the cystine residues confer upon wool fabric desirable properties such as set and crease resistance; on the other hand cystine may also be involved in yellowing and weakening of wool under adverse conditions. Following the lead provided by earlier work in this Division, the grantee has applied acrylonitrile as a stabilizing reagent for thiol groups in reduced wool protein, a technique which facilitated fractionation of the protein after enzymic digestion. Acrylonitrile also functioned as a blocking agent for terminal amino groups of peptides, an application potentially useful in the analysis of the amino acid sequences in wool protein.

3. Study of Effects of Light. Information on the effects of light upon wool is providing further insight into color changes in wool after exposure to strong light. This research is establishing a foundation for the development of treatments to eliminate undesirable effects and, in addition, has provided a lead worthy of exploration for a photobleaching process.

B. Chemical and Physical Investigations to Improve Products

1. Improvement in Dimensional Stability of Wool Fabrics. Exploratory studies on treatments to increase wool's dimensional stability were continued. It was found that in the presence of suitable catalysts (e.g., ethylene carbonate), toluylene diisocyanate reacts with wool to form a protective surface coating. Another useful combination is sebacoyl chloride, which is one of the WURLAN components, and ethylene imine, a material which is becoming commercially available at an attractive price.

Extensive tests were made with polymeric finishes for wool with a treatment similar in some respects to WURLAN. The new treatment is tentatively being

identified as WURLAN-II. In this new scheme, wool is treated with reactive polymers, and these polymers are subsequently crosslinked by a second chemical treatment. When crosslinked, the polymeric finishes are insoluble and are durable through repeated launderings. Many suitable polymers are commercially available, and with this new technique they greatly widen the range of protective finishes that can be applied to wool, including several new types of finish which were unattainable with the original WURLAN treatment.

2. Improvement in Water- and Oil-resistance of Wool Products. Several new classes of polymers containing fluorine were synthesized and their properties studied. Starting with a new and relatively cheap fluorochemical, hexafluoroacetone, novel polymers were prepared which show extraordinary promise as protective finishes for textiles. These products should be considerably cheaper than any fluorochemical finishes now commercially available. Publications describing these compounds have already generated great interest in the industry.

3. Improvement in Luster in Wool Fabrics. Luster is a quality frequently associated with luxurious fabrics and durable luster in certain types of wool fabrics is highly desired. Previously, chemical and mechanical treatments produced, at best, a temporary luster in wool. Research performed at the Harris Research Laboratories, Washington, D.C., under a research contract, has endeavored to delineate the most important factors influencing this rather evasive quality and to find treatments to enhance it. Chlorination or other treatments which chemically affect the surface of the wool fibers tend to increase the luster but at the same time to damage the strength and abrasion resistance. It was found, however, that certain fluorochemical polymers increase the luster without damage to the wool. The beneficial effect is not as large as desired, and so efforts are being made to combine mild oxidative surface treatment with the best of the polymeric finishes.

4. Exploratory Chemical Investigations. A study of wool's adsorption of selected ions was begun under a P.L. 480 grant to the Ahmedabad Textile Industries Research Association in India. This research is aimed at providing new directions for improvements in chemical modification, processing and use. Experimental results discussed in the first report are too brief for a fair appraisal of the project.

A P.L. 480 grant to the Textile Research Association of Helsinki, Finland on the interrelationships of finishing treatments, moisture, fabric handle, and tailoring qualities was concluded. Among the conclusion are the following: (a) the stability of surface smoothness after mechanical washing is better for top-dyed fabrics than for piece-dyed; (b) top-dyed fabrics are also superior to piece-dyed in creasing properties and are more stable dimensionally; (c) on top-dyed fabrics, setting treatments affect the fabric properties far more than does the mechanical action of different scouring and milling treatments; (d) from the point of view of garment manufacture, flat-setting treatments make it more difficult to produce a good seam.

One of the most important results of this project was the development of a new method for estimating the creasing properties of fabrics. The method can easily be adjusted to correspond with the conditions in which the garments are most likely to be used, e.g., in cold or heat, dry or moist climates, etc.

5. Improvements in Properties Through Application of High Energy Radiation. Research in this area, largely of a fundamental nature, is being conducted under contract at the Camille Dreyfus Laboratory of the Research Triangle Institute, Durham, N.C. It has been found that through the application of high energy radiation vinyl monomers can be polymerized and grafted to wool. When the amount of grafted polymer is less than about 20% by weight, the wool is only very slightly changed in gross physical properties, such as stiffness or texture. However, refinement of physical measurements will be needed to evaluate the changes in certain other essential properties. This work holds considerable promise, and the publications on the early phases of this project have already attracted wide interest.

C. Technology--Process and Product Development

1. Washable Wool Fabrics; WURLAN and WURLAN-II. Research and development on the application of the WURLAN treatment to wool top showed that a high degree of shrink-resistance with minimum effect on processing characteristics or softness of hand can be achieved. Key factors were defined as proper selection of reactants, optimization of treating conditions, and proper design of equipment. The addition of non-ionic softeners and fiber lubricants was found to be helpful. The WURLAN treatment, now in growing commercial use, is the first feasible application of a resin finish to wool top to achieve shrink-resistance.

Extensive pilot plant studies on the crosslinking of reactive polymers (see also 5-B-1) provided information to be used in later mill trials. Excellent stabilization of wool was achieved in pilot studies when wool was treated with reactive isocyanate polymers, which were then crosslinked with polyamines. Chemical costs of treatment should be less than for the original WURLAN, because the reactive polymers are commercially available at about half the cost of WURLAN chemicals. Much more work will be required, of course, in pilot plant and mills in order to determine optimum treating conditions for possible commercial applications.

2. Construction of Fabrics. Studies have been made of the variables in yarn and fabric construction, woven and knit, comparing not only physical construction factors such as yarn twist, but also comparing WURLAN-treated and control yarns. Efforts are being made to determine the critical factors affecting the efficiency of knitting of these yarns and the performance characteristics of the fabrics made from them.

To better understand the underlying physics and mechanics of the knitting process, a mathematical analysis has been made of the forces occurring in the weft-knitting process on conventional machinery. This study showed

that present conventional machine designs are inefficient. Large forces are created in the knitting zone, causing the yarn to break out, and knitting speeds are limited because of poor engineering. Alternate designs to increase wool knitting speeds and efficiencies have been proposed and will be evaluated.

The basic variables governing wear-wrinkling performance of light-weight wool fabrics were investigated in a contract project at the Harris Research Laboratories, Washington, D.C. The eighteen special fabrics designed, woven and finished for study included ten worsted, six woolen, and two wool/mohair blends. A series of chemical treatments was also made on portions of these fabrics. A total of 66 experimental fabrics varying in construction and chemical treatment were studied for wear-wrinkling behavior. All of the fabrics were subjected to standard laboratory tests, and from 12 of the fabrics representing the most important variables in construction and treatment, men's slacks were made and worn in two service tests. Correlations were made between the laboratory and service tests.

On the basis of this study, a wool fabric designed for minimum wrinkling in service should have the following features: it should be woven in a relatively open weave; it should be as thick (heavy) as consistent with its intended use; and it should be made from fibers as coarse as possible consistent with comfort, drape and ability to spin to the desired yarn size. Setting with bisulfite, although it did not affect crease recovery, improved the overall garment appearance. WURLAN treatment had no effect on wear-wrinkling behavior.

The information obtained will be useful as a basis for further studies, by providing a background on the interrelationships among various constructional factors and chemical treatments with respect to the wear-wrinkling properties of worsted and woolen fabrics.

3. Wool-Cotton Blend Studies. Work in this area was initiated with a study of available wool/cotton fabrics and has progressed to the point of design of new blends for further testing. The WURLAN treatment alone imparts excellent shrink-resistance to wool-cotton blend fabrics. In combination with new delayed-curing treatments now in use on cellulosics, outstanding durable-press qualities can be achieved. Experimental durable-press wool-cotton shirts, WURLANized and processed by the Koratron type of delayed cure, have gone through 20 home-laundrying, tumble-drying and wearing cycles and have retained their press without the need for any ironing.

Although these preliminary results are highly promising for the use of wool in modern durable-press blends, many problems remain to be solved. Fabrics thus treated tend to lose an appreciable degree of abrasion resistance and tear strength. There is also need for a delayed-curing resin that will crosslink with the cellulosic component at lower temperatures than now conventionally used for such curing.

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POULTRY UTILIZATION - FOOD

Western Utilization Research and Development Division, ARS

Problem. In spite of a 60% increase in production over the past decade, gross farm income from poultry meat has increased only from \$1.4 to \$1.5 billion. The poultry meat industry operates on very narrow profit margins. In order to keep up with developments in the modern food industry, poultry must be converted into a wide variety of products having high quality and convenience, at costs attractive to consumers and remunerative to the poultry grower. More information on the properties and processing of poultry is needed to enable us to better utilize poultry in a variety of forms attractive to consumers. Increased utilization of poultry would serve toward eliminating our feed grain surplus, increase returns to farmers, and provide better products for American consumers.

Although poultry is an efficient converter of feed to meat, more grain is used by poultry per calorie of food produced than by any other commercial animal because a high percentage of the poultry diet is grain and because poultry meat contains exceedingly little fat. One-fourth of all grain fed to animals is used for poultry and egg production. Hence, increased consumption of poultry products would be an effective means of increasing markets for surplus grain. Also, the efficiency of feed utilization by poultry makes prices for poultry meat low and, thus, within reach of more consumers, with the result that the nutrition of consumers who now have diets low in animal protein is improved.

The consumption of poultry has steadily increased from a 1947-1949 average of 22 lbs. per capita to 39 lbs. in 1963. This important increase has involved price, quality of product, availability, and disposable income. Because of the current low profit margin, increasing consumption by lowering farm prices is impractical. Increased demand for and consumption of poultry will require higher quality, more convenient products and a greater variety to meet the desires of the modern consumer. In addition to greater returns from increased demand, a greater profit margin for the farmer can, of course, come from greater efficiencies in processing.

The trend toward convenience foods and further processing has led primarily to precooked poultry products which are generally less stable, more subject to warmed-over flavors, and more likely to provide texture problems than are uncooked items. With the expansion of operation and the emphasis on continuous, more efficient processing, need has arisen for better procedures for feather removal, chilling, tenderizing, freezing, deboning, and commercial cooking. Lowering the cost and improving the quality of products that can be stored at ambient temperatures, such as canned, dried, cured, and irradiated products, offer potential for poultry utilization in domestic and export markets. As a foundation for applied studies, further knowledge is needed on the chemical nature of flavor and flavor changes during processing and storage, on tenderness development, and on proteins, lipids, and other components.

USDA AND COOPERATIVE PROGRAM

Basic and applied research on poultry meat and poultry meat products are conducted at the Division headquarters at Albany, California, and by contract in Madison, Wisconsin, and Berkeley, California. Fundamental studies on poultry flavor are concerned with the identification of flavor precursors in poultry meat and the isolation and identification of volatile flavor components developed during cooking. The chemistry of muscle protein and post mortem chemical changes are investigated relative to tenderness and other quality characteristics of poultry. The basic physiology of the feather-release mechanism in fowls is studied. Applied research is conducted on the stability of cold-tolerant organisms; special problems of flavor, texture and stability of precooked frozen foods; and processing factors that influence tenderness of poultry meat.

The Federal program of research in this area totals 11.2 scientist man-years, including contract research equivalent to approximately 1.4 scientist man-years per year. Of this number, 4.1 are assigned to Flavor; 4.3 to Color, Texture, and Other Quality Factors; and 2.8 to Technology--Process and Product Development.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 17 scientist man-years is devoted to this area of research.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Poultry Meat Components and Properties. Contract research at the American Foundation for Biological Research, Madison, Wisconsin, was conducted to obtain a better understanding of the ultrastructure of poultry muscle tissue and how this structure is modified by variations in aging, freezing, thawing, cooking, and related food-processing steps. Electron microscopic examinations revealed several distinct graded patterns of change in muscle tissue as it progressed from the pre-rigor to the post-rigor state. Freezing and thawing or heating had marked effects on the structure of pre-rigor muscle, but less effect on the post-rigor muscle. As expected, heating effects dominated the picture. Combined effects of successive freezing and heating or heating and freezing on pre-rigor and post-rigor muscle were largely determined by the severity of the first condition applied. These studies constitute the first essential step towards applying data on ultrastructure to the development of an explanation and a control of quality losses in poultry meat subjected to various processing operations. To follow the promising leads of this research, another contract has been negotiated with the American Foundation for Biological Research.

In research that is supported in part by the U.S. Public Health Service Career Award Program, enzymes from chicken and turkey pancreas are being

compared with their counterparts from other animal sources. Chymotrypsin isolated from chicken differed from mammalian chymotrypsin both in physical and in enzymic properties. Trypsin isolated from turkey, on the other hand, did not differ in enzymic properties from mammalian trypsin, although their physical properties differed. The yields and properties of the enzymes suggest that they perform the same role in intestinal digestion in birds that they do in mammals.

Fluoride content in the back and neck parts of commercial broilers was evaluated as a basis for decisions on the relative suitability of the hard-to-market backs and necks as a finely ground meat and bone emulsion for use in food products. Fluorine concentration in complete backs and necks (meat, skin and bone) was 20 times that in poultry meat (wet basis). About 1 mg. of fluorine would be expected from an average (56-gm.) portion of backs and necks, a value much lower than some previously reported. Cooperative studies in which broilers were fed with a wide range of phosphorus supplements indicated that the source of phosphorus in the feed is a major factor controlling fluorine content of the carcass. At present, with due consideration of the above data, the Food and Drug Administration questions the wisdom of using bone-containing poultry meat products in foods for human consumption.

B. Flavor

1. Poultry Aroma. Basic and applied research are being conducted on the factors that influence flavor of cooked poultry meat. Gas chromatography and other laboratory techniques have separated more than 200 volatile components from cooking chicken. Sensory tests are being used to evaluate fractions of the chicken aroma which were separated by absorbing (on powders or in solutions of metal salts) the volatile materials of freshly formed cooked-chicken aroma carried in a nitrogen gas stream. Some of the aroma constituents are not absorbed, and these were smelled by a trained panel and then characterized or identified by subjective evaluation prior to further chemical characterization. By means of these techniques, the important role of hydrogen sulfide in cooked-chicken flavor has been further revealed. However, other aromatic materials blend with the hydrogen sulfide or mask it to produce the characteristic aroma of cooked chicken.

Taste panel tests were used to demonstrate that the fat of chicken is not a direct precursor of basic chicken flavor. Fat separated from uncooked chicken was odorless and, upon cooking, it did not develop an odor or flavor typical of cooked chicken. However, the fat that exists in cooked chicken appears to serve as a solvent and a repository for the cooked-chicken aroma that develops in the nonfat components.

C. Color, Texture, and Other Quality Factors

1. Texture of Poultry Meat. Basic biochemical relationships between changes in poultry muscle after slaughter and the ultimate tenderness of cooked meat have been under investigation for the past 10 years, with particular attention

to the fate of certain chemicals (adenosine triphosphate (ATP), phosphoryl-creatine, glycogen, and lactic acid) involved in anaerobic glycolysis during the post-mortem period when tenderness changes occur. Treatments that accelerated the disappearance of ATP and glycogen also accelerated the onset of rigor mortis and induced a toughness that was only partially reversed by prolonged aging. Treatments included severe mechanical feather picking, freezing and thawing, holding at elevated temperature, cutting the muscle, electron irradiation, and exhaustive electrical stimulation. Breakdown of glycogen can be minimized by injecting the birds with epinephrine or sodium iodoacetate prior to slaughter, or by rapid cooking of the meat immediately after slaughter. Although these treatments accelerate rigor mortis, the resulting meat is tender without aging. Evidently, therefore, acceleration of post-mortem glycolysis, rather than acceleration of rigor mortis, induces toughness in broilers.

Economic pressure to speed up processing and eliminate extended costly aging periods has raised anew questions on required aging times for complete tenderization. Research findings from this and other laboratories indicate that small turkeys and chickens vary greatly from bird to bird in their tenderness if they are not adequately aged; that at least 8 hours of post-mortem aging at temperatures above freezing is required for chickens or small turkeys to become uniformly tender; that large turkeys (20 lb. males) are adequately tender with only 1-2 hours of post-mortem aging, although holding for an additional 18 hours significantly increases their tenderness; that rapid chilling does not alter the rate of tenderization; and that agitation and manipulation of turkey carcasses during killing do not reduce aging requirements.

In addition to sensory evaluations of tenderness, objective tests of tenderness have been made by means of the Warner-Bratzler and LEE-Kramer shear force instruments. These objective methods measure the force required to shear meat in a direction perpendicular to the fiber, and they generally correlate well with relative toughness. A simple mechanical method has now been devised to measure relative cohesiveness--the effort required to separate the fibers of a meat sample. Such data may prove useful in measuring toughness and tenderness of meat.

D. Technology--Process and Product Development

1. Freeze-drying. A rotating vacuum-freeze dryer has been designed for the continuous freeze-drying of various foods. The equipment was completely satisfactory for drying diced cooked chicken and turkey meat, vegetables, and fruits that do not tend to stick, but the problem of some products sticking to the heat-transfer surfaces has not been overcome. Commercial adoption of such a design probably depends upon development of a configuration suitable for freeze-drying products such as cut fruit pieces--especially strawberries.

Contract research at the University of California in Berkeley is underway to develop engineering information on rate-controlling factors in freeze-drying and methods of programming heat input and determining drying end points. Thermal conductivity of freeze-dried poultry meat was determined and found to be extremely low. It is influenced materially by the moisture content (conductivity increases with increasing moisture content), and it increases very slightly with increasing pressure in the dryer. Heat conduction across the grain of the meat is much poorer than along the grain. Initial data on rate-controlling processes in freeze-dryers were compared with values computed on the basis of all the water in the meat, which forms a retreating ice front as drying progresses. The mathematical model is adequate until 80% of the water has been removed from the meat, then the removal of adsorbed water slows drying and upsets the mathematical model.

The major defects in freeze-dried poultry meat are toughness and dryness. Since commercial freeze-dried poultry meat is almost always prepared from 1- to 2-year old birds, in which there is considerable connective tissue which influences the texture of the product, attention is now being directed toward this connective tissue. The influence that aging of meat may have on the tests designed to measure connective tissue content of raw muscle has been investigated. No significant changes were observed in tissues aged for 24 hours. The difference in quality between reconstituted freeze-dried poultry meat and fresh meat may be related to differences in the way water is held within and between the structural elements of the muscle. Several proteins have been isolated from muscle fiber and partially purified for study of the effects of freezing and drying conditions on their water-holding characteristics, solubility, and other properties.

Taste panels have compared tenderness of turkey samples that had been either partially freeze-dried or completely freeze-dried before cooking. The completely freeze-dried samples were tougher. These data indicate that an appreciable part of the quality loss due to freeze-drying, as in most drying processes, occurs in the later drying stages, after much of the moisture has already been removed.

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EGG UTILIZATION - FOOD

Western Utilization Research and Development Division, ARS

Problem. Between 1955 and 1965, gross farm income from eggs decreased from \$1.96 billion to \$1.81 billion, in spite of an increase in total production from 60 billion eggs to 66 billion in that time. This increase, however, represents a decline in per capita consumption from 371 to 308. Because the demand for table eggs is inelastic, increased utilization of eggs must come mainly from products that emphasize quality and convenience. Adequate knowledge is lacking of the properties, processing characteristics, and new-product potentials of eggs to develop new markets. Present outlets for the 10% of egg production that is frozen or dried include the baking, confectionery, salad dressing, noodle, and baby food trades. Modified and new products emphasizing quality and convenience are needed to increase acceptance of egg products by these industries and to compete successfully with egg substitutes. Improved egg-containing products would benefit the producer in three ways: by providing an increasingly useful buffer for stabilizing egg prices; by providing additional uses and outlets for eggs; and by providing more remunerative outlets for wholesome eggs that are unsuitable for table use because of appearance or handling characteristics.

Further basic research on egg composition and components is essential to reach an understanding of physical and chemical changes accompanying processing, storage and use of eggs. The basic information will be used to devise better processes and products, including new household and institutional products. Studies must encompass a full appraisal of physical, chemical, and microbiological problems peculiar to the formulated products.

USDA AND COOPERATIVE PROGRAM

In the Western Utilization Research and Development Division, a broad program of basic and applied research is conducted at the Division headquarters at Albany, California; by contracts and grants in Ames, Iowa, Ithaca, New York, and Davis, California; and by grant funds under P.L. 480 in France, Australia and India. Fundamental research is conducted on egg proteins and their relations to the functional properties and quality in eggs, on egg lipids and their role in off-flavor development in yolk solids, on the mechanism of bacterial penetration and survival in eggs, and on the bactericidal, antiseptic, anti-inflammatory, and food preservative properties of lysozymes and other components from eggs. Applied research is conducted on the stabilization of yolk-containing solids to increase the usefulness of eggs in dry mixes and other convenience foods, on new and improved drying procedures to make dried egg fractions and products more readily and more completely dispersible, on various methods of controlling Salmonella in eggs, and on factors in the handling of shell eggs that affect egg product quality and cost.

The Federal program of research in this area totals 13.1 scientist man-years, including contracts and grants equivalent to approximately 2.2 scientist man-years per year. Of this number 3.6 are assigned to chemical composition and physical properties; 2.9 to microbiology and toxicology; and 6.6 to technology--process and product development. In addition, three research grants are supported by P.L. 480 funds.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 14 scientist man-years is devoted to this area of research.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Composition and Methodology. Lysozymes are proteins with biological properties including enzymic and antibiotic activity. Basic investigations of lysozymes from eggs and other animal sources have been conducted at the University of Paris, France, supported by a P.L. 480 grant. In this program, lysozyme from chicken egg whites was studied to determine the relationship between chemical structure and biological activity, and compared with lysozymes from other sources. The egg white lysozyme was broken down by an amino peptidase enzyme, to yield a number of derivatives, the principal one of which remained as active as the native lysozyme.

Research supported by P.L. 480 funds at the Indian Institute of Science in Bangalore is designed to determine changes in physical chemical properties in proteins of hen egg yolks that occur on freezing and thawing, namely, the gelation of egg yolk. Egg yolk was treated with formic acid to partially remove lipids, then the residue was dialyzed to remove the formic acid solution. On dialysis, one part of the protein gelled in the dialysis bag, while the other part remained in solution. The gelled and soluble proteins were separated by centrifuging. They contained about 20 to 24% lipid, mainly lecithin, but also neutral lipids and phosphatidyl ethanolamine. The gelled protein fraction gels in 50% aqueous formic acid, whereas the soluble protein fraction forms only a viscous solution with 50% formic acid. Both fractions gel instantly in a solution of 50% dimethyl sulfoxide and 50% formic acid. The chemical treatments used may have denatured the egg yolk proteins so they no longer are closely related to the native protein. Nevertheless, the information will be helpful in developing a thorough understanding of the elusive mechanism(s) involved in the marked change in physical properties of yolk that occurs on freezing.

A basic study of ovalbumin in eggs is being conducted at the Commonwealth Scientific and Industrial Research Organization, Ryde, New South Wales, Australia, supported by P.L. 480 grant funds. Ovalbumin, the main protein of egg white, occurs in two forms which differ greatly in resistance to denaturation but are otherwise very similar. The more stable form, S-ovalbumin, is formed from the original ovalbumin during the storage of

whole eggs and can also be produced from isolated ovalbumin by storage in slightly alkaline solution. It was postulated that the change involved a change in the disulfide bonding. Analyses of the chemical structure of ovalbumin and S-ovalbumin indicate that the differences in stability are not associated with differences in the intramolecular disulfide bonding that holds the untreated proteins in the coiled or folded form. Thus far only the fragments containing disulfide bonds have been examined. In future work, other parts of the ovalbumin and S-ovalbumin molecules will be scrutinized.

In-house research coordinated with the P.L. 480 projects involves isolation of individual egg proteins and characterization of their physical and chemical properties, particularly properties that might be related to the contributions of individual proteins to useful properties of egg products. Heat stabilities of different egg white proteins have been evaluated relative to the thermal destruction of Salmonella contaminants. Lysozyme is rapidly destroyed when heated in egg white at pH 9. Ovalbumin is converted to the more heat-stable S-ovalbumin. The destruction of lysozyme is the result of a reaction with ovalbumin, even though ovalbumin by itself is not appreciably denatured under these heating conditions. When egg white at pH 9 is heated to temperatures slightly above 57° C., the viscosity increases and foaming power decreases. These changes are not yet understood in terms of changes in individual egg white components, however they undoubtedly involve the lysozyme-ovalbumin reaction and other proteins. Improvements in the properties of egg products, including the performance of pasteurized eggs, depends on our understanding and control of such changes in individual proteins.

Basic studies are underway to characterize two globulins of egg white about which there is very little information. One globulin, as yet unidentified except by differentiation in electrophoretic equipment, has been fractionated, and evaluation of its molecular weight is underway.

B. Microbiology and Toxicology

1. Spoilage and Pathogenic Microorganisms. The microbiology of spoilage and control of pathogens in egg products continue to dominate the interests in egg utilization research (see also C. Technology--Process and Product Development). The most prevalent type of pathogen that contaminates egg products is Salmonella. An egg white pasteurization method has been developed that allows use of temperatures up to 62° C. without coagulation of egg white protein. A temperature of 60-62° C. for 3-1/2 min. is adequate to destroy ordinary Salmonella contaminants in whole egg and neutralized egg white. One strain of Salmonella, however, Salmonella senftenberg 775W, which was isolated in another laboratory in 1946, is 10 to 20 times as heat resistant as other senftenbergs or other Salmonella species. Although re-isolation from food of this heat-resistant strain has never again been reported, the strain has been maintained in laboratories and its heat resistance studied extensively. Major concern exists about the variable heat resistance of the 800 to 900 different sero-types of Salmonella. Several hundred have been tested, and only one type, other than the S. senftenberg mentioned, showed

somewhat higher than normal heat resistance, but it was much lower than the S. senftenberg 775W. Danger from this one strain is minor to negligible. One report in the literature indicates that Salmonella heated in ground chicken muscle has greater heat resistance than does the same type heated in a broth suspension. Our studies with Salmonella of normal heat resistance and with the highly heat-resistant S. senftenberg 775W show that heat resistance of Salmonella in ground chicken muscle is similar to its heat resistance in other media.

A research grant was made to Cornell University to study the selenium metabolism of Salmonella, because it is known that these microorganisms grow more readily than other microorganisms on selenite media. The selenite cysteine medium, which is selective for Salmonella, loses its selectivity if glucose or 10% egg white is added. These findings may explain the variability sometimes encountered in assaying for Salmonella at very low levels of contamination, where the large samples required introduce significant amounts of glucose and egg white to the medium. Continuation of this work is expected to lead to more reliable methods.

Contract research to determine factors contributing to Salmonella contamination was concluded at Iowa State University. Direct inoculation of hens' ovaries yielded only 10 out of 38 eggs with Salmonella contamination, and that at a very low level. When hens were fed the inoculum, they did not produce eggs containing Salmonella, but oral inoculation did lead to shedding of viable Salmonella in the feces for up to 17 days after exposure. Shells of some eggs laid by such hens were contaminated with Salmonella and led to subsequent microbial contamination. Such data emphasize the importance of providing Salmonella-free feed to laying hens, since the major source of contamination of eggs is from extraneous sources.

Salmonella contaminating the shells of eggs normally does not penetrate to the egg contents, and generally the organisms decrease in number in the shell membrane system if the eggs are kept dry. The bacteria do multiply on the shells and in the membrane system in an atmosphere at 15 to 40° C. and 100% relative humidity. The numbers on the shells of washed eggs decrease by about 99% during the first 2 hours of drying. In breaking plants, a primary source of contamination of liquid egg is the flora on the egg shell, and the incidence of Salmonella contamination is increased when the general bacteriological quality of the shell eggs used for production of liquid egg is poor. Sanitizing agents and ethylene oxide treatments destroy Salmonella on the shells and in the shell membrane system. Careful plant sanitation and use of high-quality eggs can reduce the contamination of liquid egg but, in addition, pasteurization is necessary for the complete elimination of Salmonella from broken out eggs.

C. Technology--Process and Product Development

1. Pasteurization of Egg Products. Egg products that contain Salmonella are considered to be adulterated and, therefore, cannot be sold. Department

of Agriculture poultry inspection regulations went into effect in June 1966 requiring freedom from Salmonella in egg products. The regulations specify pasteurization conditions that will assure freedom from Salmonella. Egg products so treated under continuous Department inspection need not be further tested for Salmonella contamination. Egg products prepared without the specified processes, or produced in the absence of Department continuous inspection, must be tested by a suitable method for absence of Salmonella before they can enter interstate trade channels. One of the methods specified was developed at the Western Utilization Research and Development Division. Aluminum salts are added to the liquid white and the pH reduced to stabilize the components against heat, then the egg white can be pasteurized at temperatures high enough to control Salmonella. A public service patent, No. 3,251,694, was issued May 17, 1966 and 48 commercial egg processors have received licenses to operate under the patent.

Although most properties of egg white are unchanged by the new pasteurization process, whipping time of the egg whites is increased. Basic and applied research on this damage is being conducted. A new whipping aid, triethylphosphate, has been found that is very effective in reducing the whipping time; application for a public service patent on this use has been filed.

Effect of pasteurizing temperatures on fluidity of various egg products is being determined. At suitable pasteurizing temperatures, just over 60° C., egg whites are only 2 to 3 times more viscous than water, and whole egg only 6 to 8 times. Yolk and sugared yolk are 200 to 400 times more viscous than water, and salted yolk is so viscous that its flow characteristics are very difficult to measure. A high level of viscosity will reduce pasteurizing efficiency, because flow becomes laminar, and the minimum residence time in holding tubes will be shorter than the calculated average. Attempts are being made to find an enzyme test that can be used to determine when egg products have received an adequate pasteurization treatment. The phosphatase test used for milk and milk products is not suitable because this enzyme is not inactivated by present pasteurization procedures.

Contract research is being conducted at the University of California at Davis on potential methods for eliminating Salmonella from egg products by chemical treatment. Hydrogen peroxide in concentrations from 0.3% to 3.0% is being tested over a range of acidity, without heating and with heating at 47° C. (117° F.). Preliminary tests show that the peroxide can adversely affect the conalbumin and perhaps the ovalbumin also. Peroxide caused marked changes in the lipid fraction of the yolk. It appears unlikely that peroxide could be used in a process for pasteurizing yolk-containing products, although the results obtained do not invalidate the heat plus peroxide method now being used to pasteurize egg whites.

Contract research has been initiated at Iowa State University in Ames to evaluate chemical, physical, and enzymic means of altering the functional properties of egg white to develop improved or new egg white products. Initial work involved the selection of methods of analysis and evaluation. Limited observations on egg white treated with the protein-modifying agent, potassium peroxydisulfate, show that readily detected chemical modification can occur without damage to functional properties. These results encourage further studies.

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III. MARKETING AND ECONOMIC RESEARCH

DAIRY PRODUCTS - MARKET QUALITY

Market Quality Research Division, ARS

Problem. Dairy products in marketing channels are subject to deterioration by microbiological action and by oxidative processes. In addition, several kinds of insects and mites may contaminate or damage dairy products during storage and distribution. Improved tests for estimating initial quality and information on factors influencing keeping quality would be useful to minimize deterioration in marketing channels. There is also a need for simple, accurate tests for estimating fat, solids-not-fat, and protein in all types of dairy products in order to maintain accurate control of composition and to permit realistic pricing of milk. Pasteurized milk invariably spoils within a week or two from bacterial growth in refrigerated storage. Information is required on the source of the spoilage organisms and on how they may be eliminated. Safe and effective methods of preventing or controlling insect and mite infestations are needed. More information is needed on the storage-life of butter and butteroil under various conditions and on the factors which predispose these products to deterioration. Contamination by pesticides residues continues to be a major problem. Simplified methods are needed of detecting such residues in dairy products and also in feeds so that excessively contaminated products may be removed from marketing channels.

Modern marketing practices in the dairy industry have intensified the problems of detecting inferior lots of milk and of increasing the storage-life of dairy products. Several kinds of insects and mites contaminate or damage dairy products during processing, storage, and distribution. To maintain quality of these products in marketing channels, research is needed on the factors influencing keeping quality; on developing new and improved objective quality tests for bulk milk and other products; on developing safe and effective procedures for preventing or controlling insect and mite infestations; and to find improved and simplified detection methods for antibiotic and pesticide residues in dairy products.

USDA AND COOPERATIVE PROGRAM

There is a continuing program of basic and applied research aimed at developing new and improved methods for assessing the important quality factors in a variety of dairy products. At Beltsville, Maryland, studies of the shelf-life of canned butteroil and ghee, prepared from cold storage butter, has been completed. (MQ 3-49) Work on chlorinated pesticide residues in dairy products has been expanded to cover feeds and forages. A detailed study of procedures for direct microscopic counting of bacteria in milk has been completed. (MQ 3-76) Work on moisture distribution in butter is continuing. The Federal scientific effort devoted to research in this program totals 1.0 scientific man-years.

A program headquartered at Fresno, California, involved basic and applied entomological research directed toward the prevention of insect and mite infestation in dairy products in the marketing channels. The Federal effort on this program during the reporting period was 1.0 scientist man-year, of which 0.6 man-year was in contract research. The entomologist was at the University of Wisconsin doing graduate work under the Division's training program. Much of the cross-commodity research at Savannah, Georgia, reported in Area 13, "Insect Control in Marketing Channels," is also applicable to the problems in dairy products.

A 2-year contract with the Stanford Research Institute is for a study to identify and synthesize the natural attractants in certain dermestid beetles.

A grant to the Tokyo University of Agriculture, Tokyo, Japan, is for a 3-year study part of which is on the constituents of dairy products that attract mites. It continues until August 1968, and involves PL 480 funds with a \$38,622 equivalent in Japanese yen.

Line Project MQ 1-6 on mite fumigation studies was terminated in February 1966.

PROGRAMS OF STATE EXPERIMENT STATIONS

A total of 16 scientist man-years is devoted to this area of research.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective Measurement of Quality

1. Stability of Anhydrous Butterfat. All samples opened after two years' storage at 32°, 70°, and 100°F. exhibited obvious deterioration. (MQ 3-49)

2. Moisture Distribution in Butter. A commercial conductance meter with special electrodes proved satisfactory for measuring electrical conductance in butter. Polarization effects were eliminated by dipping the electrodes in a dilute salt solution between readings. No clear correlation has been found between electrical conductance and keeping quality; however, samples of high conductance were visibly "leaky." (MQ 3-57)

3. Pesticide Residues. An improved technique for thin layer chromatography was developed which incorporated silver nitrate in the plate as a chromogenic agent plus a small amount of oxidized fat to suppress interference from fat in the samples. The method will easily detect 0.01µg of

most common chlorinated insecticides. Studies of the analyses of various types of livestock feeds using thin layer chromatography were begun, using a one-gram sample of dry feed. Four samples require about $2\frac{1}{2}$ hours for analysis. (MQ 3-70)

4. Direct Microscopic Counts. Work was completed on a study of the correlation between standard plate count (SPC) and four direct microscopic counting (DMC) procedures. The DMC stains used were (A) the Levowitz-Weber methylene blue stain, (B) a modification of (A) incorporating basic fuchsin, (C) alcohol-acetic acid fixation followed by a periodic acid-bisulfite-toluidine blue stain, and (C) alcohol-acetic acid fixation followed by stain with toluidine blue buffered to pH 4.0. Correlations between DMC and SPC were greatly affected by the type of bacteria and the staining procedure used but were not affected by such factors as the number of fields counted for DMC, the position on the DMC smear, or by using various definitions of clumps (touching, within 1 cell diameter, within 2 cell diameter) for the DMC. Using stain A for example, the correlation between DMC and SPC ranged from 0.930 for Pseudomonas fluorescens to 0.146 for Bacillus subtilus. For all bacteria, correlations between SPC and DMC were: Stain A, 0.858; Stain B, 0.429; Stain C, 0.685, and Stain D, 0.917. The precision of the DMC varied directly with the number of cells in the sample but varied inversely with the square root of the number of fields counted. The precision of counting was not affected by the staining procedure used. (MQ 3-76)

B. Prevention of Insect Infestation

1. Biological and Physical Control. About 30,000 female black carpet beetles are reared each month for collection of sex attractant either by aeration or by maceration in benzene. The active components can be manipulated by high-vacuum short-path distillation, column chromatography, thin layer chromatography and chemical treatment but not by gas chromatography. The threshold of response of the males generally occurs at a concentration of 1/10,000 female equivalent. The preliminary work conducted indicates that full-scale attempts to isolate and identify the active compounds can now be undertaken. A manuscript on the collection of the pheromones with absorption columns has been accepted for publication in the Journal of Economic Entomology. (MQ 1-32(C))

There was no difference in the luring activity of five varieties of cheese to the cheese mite. Studies, therefore, are under way to isolate the volatile attractive compounds from Cheddar cheese. (All-MQ-3(a))

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Prevention of Insect Infestation

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Quality Maintenance in Storage

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LIVESTOCK AND MEAT - MARKET QUALITY
Market Quality Research Division, ARS

Problem. To insure that grades are a true measure of palatability, a better understanding of the relationship between the physical and chemical properties of muscle and quality must be established. This information can then be used to devise objective methods for measuring the degree of tenderness, juiciness, and flavor in meat cuts.

The dominant method of merchandising meat in retail stores today is through the use of self-service display cases. Therefore, quality and appearance of the meat is of primary importance and research on maintaining meat quality and shelf-life is a necessity for the success of this type of merchandising. Lighting conditions required to evaluate meat quality need to be defined so that the meat quality attributes can be properly assessed.

The maintenance of desirable meat quality during various transport techniques and the determination and evaluation of the various methods of shipping fresh meats to European markets are primary research needs if we are to expand our market for fresh meats.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program involving chemists and food technologists in basic and applied research on quality maintenance, and development of objective methods for quality evaluation of meat. This work is conducted at Beltsville, Maryland, partly in cooperation with the Animal Husbandry Research Division, Agricultural Research Service, the Livestock Division, Consumer and Marketing Service, the Radiological Laboratory of the Johns Hopkins Medical Institutes, and Texas A&M, and partly by contract with the Universities of Wisconsin, Illinois, and Texas A&M.

The Federal scientific effort devoted to research in this area exclusive of contract research totals 7.9 scientific man-years divided as follows: quality evaluation, 6.9, and quality maintenance, 1.0.

A research grant to the Research Center of the Meat Industry, Helsinki, Finland, provides for a study on the effects of carbon dioxide or nitrogen on chemical and physical properties of refrigerated meats. Its duration is four years, 1963-1967, and involves PL 480 funds with a \$44,454 equivalent in Finnmarks.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 20 scientist man-years is devoted to this area of research.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective Measurement and Evaluation of Quality

1. Relationship of Marbling to the Palatability of Beef. A correlation appears to exist between the concentration of phospholipids, triglycerides and tenderness as measured by mechanical tests and by taste panels. As the ratio of phospholipid to triglyceride increases, tenderness decreases. More than 80 percent of the measurements made follow this pattern. Contribution of the fatty acid composition and soluble and insoluble collagen factors to tenderness are under study.

Rapid non-chromatographic procedures have been developed for separating total lipids into phospholipids, triglycerides and free fatty acids and improvements have also been made in determining the fatty acid composition of these classes. (MQ 3-60)

2. Objective Methods for Measuring Maturity. Studies of beef and chicken muscle proteolytic activity were continued. A quantitative method for the determination of a proteolytic enzyme in beef muscle optimally active at pH 9.0 was developed. An enzyme preparation having a seventeen-fold increase in specific activity was obtained. The proteolytic activity of five muscles from each of five beef carcasses was determined. Tenderization of beef muscle occurs more slowly than tenderization of chicken muscle. This may be due to the fact that chicken muscle had 2- to 3-fold more proteolytic activity.

A tracer study has been started, in cooperation with the Radiological Laboratories of Johns Hopkins Medical Institutes to test the hypothesis that uptake of radioactive strontium by the growing portion of a bone (the epiphyses) will be more rapid in younger, i.e., faster growing animals, and hence would be a measure of physiological maturity. Prior to applying the technique to beef animals, preliminary experiments in cooperation with our Poultry Investigations group have been performed with a less expensive species with faster maturity (chickens). (MQ 3-62)

3. Palatability of Ovines. Under cooperative agreement with the Texas A&M University, research will be initiated to study, identify and evaluate the relationships of chronological age, physiological maturity and carcass quality factors which are considered important in the palatability of lamb and mutton. (MQ 3-34)

B. Quality Maintenance in Handling, Packaging, Storage and Transportation.

1. European Fresh Beef Shipments. Research on the techniques of shipping beef to European markets has been conducted in cooperation with the Transportation and Facilities Research Division, Agricultural Research Service. A test of a forty-foot refrigerated van container to transport fresh hanging beef from Texas to Germany was conducted. German meat inspection regulations require that either the whole head or the lower jawbone, including the masticatory muscles, for each fresh beef carcass

accompany the meat shipment. After 18 days in transit, the beef carcasses showed some areas of dehydration and discoloration; however, the whole heads, which accompanied this shipment, showed considerable bacterial growth which produced a stale, musty odor throughout the load of beef. (MQ 2-75)

2. Lighting Requirements for Evaluation of Meat Quality. A survey of lighting conditions of 56 representative meat packing establishments at four main stations, New York, Kansas City, St. Paul, and Seattle, was completed. Establishments where meat is Federally graded were placed into three classifications: (1) Excellent; (2) Average, and (3) Marginal, based on a subjective appraisal of the lighting conditions by the main station supervisors of the Meat Grading Branch, Consumer and Marketing Service. The average light intensity of these three classifications was 28.75 f. c., 20.97 f. c., and 14.13 f. c., respectively. Quality of light was not as variable. Most establishments used incandescent-type bulbs for sources of light in beef coolers. Fluorescent-type of lighting was found in only a few establishments.

Laboratory tests on the effect of type of light and light intensity upon the evaluation of marbling and color of meat by a panel of expert meat graders have shown little difference in overall acceptability between the type of light when intensity levels are equal. However, low level light intensities (15 foot candles) were judged less acceptable for evaluating marbling and meat color. (MQ 3-59)

3. Effect of Atmospheres of Carbon Dioxide and Nitrogen on Properties of Refrigerated Meats. Studies on the keeping qualities of beef slices held at $0^{\circ}\text{C.} \pm 0.5^{\circ}\text{C.}$ and 95 percent \pm 2 percent relative humidity with 10, 20, 30, 40, and 100 percent CO_2 concentrations have been reported. New investigations on the influence of various concentrations of N_2 have been conducted. It was found that to store beef as long as possible in faultless condition, the least possible initial microbial contamination of the surface was of prime importance. Shelf-life seems to diminish linearly with initial number of microbes. According to organoleptic observations, the keeping time of the control meat was 12 days in all test series and that of test meat was 26 days (10 percent CO_2), 33 days (20 percent CO_2), 27 days (30 percent CO_2), 40 days (40 percent CO_2), and 49 days (100 percent CO_2). (E8-AMS-5(a))

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurement and Evaluation of Quality

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Quality Maintenance in Storage

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WOOL AND MOHAIR - MARKET QUALITY
Market Quality Research Division, ARS

Problem. Wool fineness, variability, and color are the most important quality characteristics in determining the grade and consequently the economic value of wool. However, present methods of determining wool fineness and variability are slow and tedious and the causes of yellow coloration of raw wools are not known. Animal fibers in raw or manufactured form are subject to damage by several kinds of fabric insects, estimated to cause at least \$350 million loss annually. Basic research on the physiology and chemistry of wool digestion by insects is needed to provide information that can be used in developing better preventive treatments. The safety of several compounds now used for mothproofing wool has been questioned, and safer effective treatments are needed.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program involving chemists and engineers in basic and applied research on the quality evaluation and development of objective methods for quality evaluation of raw wool. The research is conducted at Beltsville, Maryland, and under a research contract with the University of Wyoming.

Line Project MQ 3-92(C) covering a study of "the interrelationships of wool fineness, softness, quality and market evaluation of domestic wools" was initiated during this period.

Under a P.L. 480 grant to the Shrim Ram Institute for Industrial Research, Delhi, India, research is underway on the "canary coloration" of raw wools. Its duration is for 5 years, 1963-1968, and involves P.L. 480 funds with a \$92,536 equivalent in rupees.

The Federal effort devoted to research in this area of quality evaluation was 1.0 scientist man-year.

There is also a continuing program headquartered at Savannah, Georgia, involving applied research in entomology and chemistry, directed toward the protection of wool and other animal fibers against insect damage. The research is conducted in cooperation with the Armed Forces Pest Control Board and various industry groups.

A 1½-year contract with the Harris Research Laboratories became effective in June 1965, to study the physical and chemical factors affecting the sorption and retention of quaternary ammonium compounds by wool. Another contract with the same Laboratories, for a 2-year study to develop procedures for applying quaternary ammonium compounds as mothproofing treatments, became effective in June 1966.

The Federal effort devoted to research on the protection of wool against insect damage is 1.7 scientist man-years, of which 0.5 is under research contract. Some of the cross-commodity research at Savannah, Georgia, reported in Area 13, "Insect Control in Marketing Channels," is also applicable to the insect problems in wool.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 2 scientist man-years is devoted to this area of research.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality

1. "Canary Yellow" Coloration of Raw Wool. Results on a wide variety of unstained and canary stained fleeces for yolk and pigment content have confirmed the earlier observation that canary coloration is mainly caused by the entry of suint pigments into the fiber whenever the grease content is too low to act as a barrier and that the canary coloration of fleeces was not due to photochemical oxidation of either tyrosine or tryptophan constituents. It was found that prolonged exposure to humid atmosphere was not directly responsible for canary coloration. It has been possible to impart canary color to white wool by staining with pigments extracted from canary colored wools. Also, significant differences have been observed in behavior towards permanent set in canary stained and unstained wools of the same quality. (A7-AMS-12)

2. Sample Preparation of Wool for Fineness Determination by Coulter Counter Technique. Studies on the factors involved in cutting wool fibers uniformly into length of 100 microns have been conducted, including the use of shrinkable plastic tubing for holding the wool fibers, means of supporting and advancing the fiber bundle, angle of the cutting blade and effect of different anvil materials. Results showed that when a tuft of wool is drawn through a short length of shrinkable plastic tubing, then shrunk, the wool fibers become axially aligned, and tightly packed in a bundle which is

convenient to handle. These bundles of fibers are placed in a micrometer advancing jaw and a channeled anvil support to be cut with a razor blade which is mounted at a 6° cutting angle. Using these techniques for cutting, wool samples have produced wool fibers of 100 μ with a standard deviation of 12 μ . These cut wool samples can then be used to determine wool fineness using the Coulter Counter Technique. (MQ 3-69(C))

B. Prevention of insect infestation

1. Nontoxic Mothproofing Treatments. Of 29 candidate compounds tested, five were found promising: Shell SD 8211, BAY 45515, BAY 58733, BAY 69047, and BAY 77488. BAY 77488 was found particularly promising because of its extremely low mammalian toxicity, 8,000 to 10,000 mg./kg. oral LD₅₀ for rats, and its effectiveness at very low concentrations. A calculated deposit of 0.0025 percent by weight of the cloth protected the fabric against damage by the larvae of the black carpet beetle, and a calculated deposit of 0.005 percent satisfactorily protected the cloth after three drycleanings. BAY 77488 produced some yellowing when applied to undyed test fabric but there was no visible staining on dyed cloth. A closely related compound, more stable and less staining, is being investigated. Poly-substituted nitrogen compounds (Polysubs) continue to appear promising after application studies conducted in home-type washing machines. The treatments were very effective although there were indications of uneven distribution of the compound on the cloth. (MQ 1-26)

Studies on the sorption and retention of quaternary ammonium (QA) mothproofing compounds have shown that not all QA compounds are adsorbed at the same rate. In general, (1) increasing the temperature and pH increases add-on, (2) increasing time only slightly increases add-on, and (3) increasing the concentration of the QA in the bath greatly increases add-on but has little effect on the percentage of exhaustion from the bath. (MQ 1-49(C))

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Prevention of Insect Infestation

U. S. Dept. of Agr., MQRD. 1966. Protecting woolens against clothes moths and carpet beetles. Home and Garden Bul. No. 113, 8 pp., April. (MQ-1)

PUBLICATIONS -- STATE EXPERIMENT STATIONS and COOPERATIVE PROGRAMS

Davis, S. P., and J. W. Bassett. 1965. The influence of age on fiber diameter, staple length, and yield of mohair. Tex. Agr. Expt. Sta. PR-2344. (Tex.)

POULTRY PRODUCTS - MARKET QUALITY
Market Quality Research Division, ARS

Problem. Technological developments continue in the poultry industry and create many new problems relating to the market quality of poultry and egg products. Introduction of highly mechanized equipment and machinery plus new techniques in processing affect the absorption and retention of moisture of ready-to-cook poultry, the contamination of poultry and egg products by spoilage microorganisms, the physical damage to poultry carcasses, and the sanitary and functional properties of egg products. To maintain quality of these products in marketing channels, more information is needed regarding the effects of the new technology as well as changes that occur during transportation and storage. In addition, objective methods of quality evaluation are needed for use in developing improved criteria and standards for inspection and grading to insure uniform, standardized, and wholesome products.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program involving food technologists and bacteriologists engaged in basic and applied research in the quality evaluation and quality maintenance of poultry products. The research is conducted at Beltsville, Maryland, Athens, Georgia, and through a research contract with the University of Iowa, Ames, Iowa.

The Federal scientific effort devoted to research in this area totals 4.8 scientific man-years; objective measurement and evaluation of quality, 3.8, and handling, packaging and storage, 1.0.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 12 scientist man-years is devoted to this area of research.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Quality Measurement and Evaluation of Quality

1. Detection of Salmonella in Egg and Poultry Products. A simple method of detecting Salmonella negative samples of dried whole egg within 48 hours has been developed. The technique consists of incubating a sample of egg in a jar of lactose pre-enriched broth containing a tube of SIM agar and one of mannitol agar. Absence of both H₂S production and mannitol fermentation after 42 hours of incubation indicate that the sample is Salmonella negative.

Of 225 samples of commercially pasteurized dried whole egg, two-thirds of the 217 confirmed negative samples were identified by this method. Employing the conventional methods, 96 hours were required to detect only 118 of the negative samples. All eight confirmed positive samples were presumptively positive by the new technique. (MQ 3-74)

2. Lighting Requirements for Proper Grading and Inspection of Poultry. A survey conducted in the Delmarva area showed a large variation in the kind and amount of light used at inspection and grading stations in poultry processing plants. A study was initiated to ascertain the parameters of an adequate visual environment for inspectors and graders. Twelve different lighting systems were evaluated by a 12-member panel who judged selected pairs of color chips which approximate the colors most critical in the inspection and grading of individual carcasses. For each pair of chips, judges were asked to indicate whether the two chips matched or were different in color when presented under each of the lighting situations at both 50 and 100 foot candles. Preliminary analysis of the data for the lower intensity, 50 foot candles, showed considerable variation between lamps on the basis of total erroneous judgments by each judge. Intensive analysis of the data is currently underway. (MQ 3-52)

B. Quality Maintenance in Handling, Packaging and Storage

1. Control of Salmonellae on Eviscerated Chickens. Eviscerated fryer chickens inoculated with S. typhimurium were spray treated with plain water (controls), citric acid, succinic acid, B-propiolactone, aureomycin, neomycin, or 20, 100, or 200 ppm chlorine solutions under conditions that simulated practical plant conditions. Only treatment with 100 or 200 ppm chlorine was significantly more effective than plain water in reducing Salmonellae counts. Washing after treatment also significantly reduced Salmonellae counts. (MQ 2-75)

2. Packaging of Eviscerated Chickens. The effect of evacuated, heat-shrunk packaging of fresh chickens on drip loss, shelf-life and general appearance was determined in a cooperative study with the Department of Poultry Science, University of Maryland. The treatments studied were: (1) non-evacuated bag (control); (2) evacuated bag; (3) heat-shrunk evacuated bag; (4) heat-shrunk, wax-coated, evacuated bag. The packaged birds were stored at $1.7 \pm 0.5^{\circ}\text{C}$. and sampled for drip loss, appearance, and bacterial populations at day of packaging and at eight intervals thereafter until the 22nd day of storage. Drip losses from birds packaged in evacuated bags were lower than the drip losses in the non-evacuated controls. Differences in total aerobic bacterial counts among birds packaged by the four methods were considered unimportant when birds were stored up to 14 days. Odor scores indicated that birds in evacuated, wax-coated bags developed objectionable odor later than did birds of the other three treatments. Birds in the evacuated heat-shrunk packages and birds in the evacuated heat-shrunk, wax-coated packages had more eye appeal than the birds in the non-evacuated bags. (Exploratory Work)

3. Microbiology of "Further-Processed" Turkey Products. A study to determine the incidence and source of Salmonellae, staphylococci and total aerobes in turkey rolls was initiated under contract with Iowa State University. Samplings were made from ready-to-cook turkeys, materials, equipment and hands of plant personnel for determination of Salmonellae and other bacteria at various stages during commercial processing cooked turkey rolls that are marketed in the frozen state. Finished raw rolls before freezing appeared to yield greater recoveries of Salmonellae than did the chilled but unfrozen carcasses used for making the rolls. Examination of 37 turkey rolls after cooking in commercial water baths revealed no Salmonellae. Limited data on numbers of aerobes, coliforms and enterococci on chilled carcasses and meat at various stages of preparation and rolls before cooking indicated that wide ranges may be expected within these three groups of bacteria. No correlation was observed between these counts and presence of Salmonellae. Salmonellae were found on various types of equipment and utensils in plants. Data concerning incidence and serotypes are being evaluated to obtain a more complete picture of the dissemination of these organisms throughout processing operations. (MQ 2-113(C))

Work was initiated to determine and eliminate the source of microbial contamination of dry-heat cooked turkey rolls that are marketed in the refrigerated condition. Cooking juices and spices used in preparation of this type of roll, as well as skin and internal meat of finished rolls obtained from four commercial plants were examined for numbers of aerobes, psychrophiles, coliforms, enterococci, molds, and yeasts. Celery, onion, pepper and cooking juices were found to be highly contaminated with both mesophilic and psychophilic bacteria. Samples of typical cooking juice - spice mixtures that are added to turkey rolls after cooking (immediately prior to packaging) were heated to 160, 180, 200, and 212°F. to determine the effect of such heat treatments on destruction of viable microorganisms. These data are being analyzed. (MQ 2-121)

4. Changes in Eggs During Cold Storage. Thick/thin white ratio, viscosity, pH, and Haugh units were found to be inter-related in oiled and unoiled eggs stored at 0° and 15°C., and unoiled eggs in a CO₂ atmosphere at 0°C. Ovomucin content and characteristics in egg white fractions were determined by specific electrical conductivity, paper electrophoresis and paper chromatography. In eggs stored for six months, ovomucin content tended to increase in thin egg white, and decrease in thick egg white. Ovomucin was found to be polydisperse. Further evidence is required to establish the quantitative relationship between amino acids and ovomucin electrophoretic fractions. (E25-AMS-8(a))

5. Maturity Studies. Preliminary investigations of uptake of radioactive strontium (85 and 87), by bones of White Leghorn and New Hampshire chickens of various ages were completed. Monitoring procedures proved effective. One-hour measurements of radioactivity of the epiphyses centers of the tibia of birds 4, 6, and 10 weeks of age yielded a constant assimilation rate. Older birds are being evaluated to determine whether the assimilation rate will change. (Exploratory Work)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Quality Measurement and Evaluation of Quality

- Kotula, A. W. 1966. Variability in microbiological samplings of chickens by the swab method. Poultry Science 45:233-236. (Exploratory Work)
- Sadler, W. W., R. Yamamoto, and R. E. Corstvet. 1965. Bacteriological survey of market poultry livers. Poultry Science 44:993-998. (MQ 3-22(C))
- Sadler, W. W., and R. E. Corstvet. 1966. The effect of Erysipelothrix insidiosa (rhusiopathae) infection on wholesomeness of market turkeys. American Journal of Veterinary Research 26:1429-1436. (MQ 3-22(C))
- Sadler, W. W., and R. E. Corstvet. 1965. The efficacy of ante-mortem inspection in supplementing the post-mortem inspection of poultry. Avian Diseases 9:441-459. (MQ 3-22(C))
- Sadler, W. W., and R. E. Corstvet. 1965. The effect of experimental mycoplasma synoviae infection in the wholesomeness of young market age chickens. American Journal of Veterinary Research 26:1413-1420. (MQ 3-22(C))
- Sadler, W. W., and R. E. Corstvet. 1965. Effect of experimental mycoplasma synoviae infection on the wholesomeness of young adult turkeys. American Journal of Veterinary Research 26:1421-1428. (MQ 3-22(C))

Quality Maintenance in Handling and Packaging

- Thomson, J. E., A. J. Mercuri, J. A. Kinner, and D. H. Sanders. 1966. Effect of time and temperature of commercial continuous chilling of fryer chickens on carcass temperatures, weight and bacterial counts. Poultry Science 45:363-369. (MQ 2-75)
- Kotula, A. W., and N. V. Helbacka. 1966. Blood retained by chicken carcasses and cut-up parts as influenced by slaughter method. Poultry Science 45:404-410. (MQ 2-81)
- Kotula, A. W. 1966. Poultry in the convenience food market. The Maryland Poultryman. January, pp. 2-4, 7. (MQ 2- and 3-)

PUBLICATIONS -- STATE EXPERIMENT STATIONS AND COOPERATIVE PROGRAMS

Objective Measurement and Evaluation of Quality

- Cotterill, Owen J. 1965. Evaluation and measurement of quality of poultry and eggs. In Food Quality, ed. by G. W. Irving, Jr., and S. R. Hoover, pp. 179-191. (Missouri)

- Essary, E. O., and L. E. Dawson. 1965. Quality of fryer carcasses as related to protein and fat levels in the diet. I. Fat deposition and moisture pick-up during chilling. Poultry Science 44(1):7-15. (Virginia)
- Meredith, W. E., H. H. Weiser, and A. R. Winter. 1965. Chlortetracycline and oxytetracycline residues in poultry tissues and eggs. Applied Microbiology 13(1):86-88. (Ohio)
- Pangborn, Rose Marie, Nancy Sharrah, Harriet Lewis, and A. W. Brant. 1965. Sensory and mechanical measurements of turkey tenderness. Food Technology 19(8):86-90. (California)
- Sluka, S. J., E. L. Besch, and A. H. Smith. 1965. A hydrostatic tester for egg shell strength. Poultry Science 44(6):1494-1500. (California)
- Taylor, M. Hal, Jack L. Fry, and Lewis T. Smith. 1965. Factors affecting quality and tenderness in turkey steaks. Poultry Science 44(3):669-673. (Kansas)

Quality Maintenance in Handling, Packaging and Storage

- Hartung, T. E. 1965. The influence of temperature and bag breakage on the quality of frozen turkey carcasses. Poultry Science 44(2):459-466. (Colorado)
- Miller, W. O., and K. N. May. 1965. Tenderness of chicken as affected by rate of freezing, storage time and temperature, and freeze drying. Food Technology 19(7):147-150. (Georgia)
- Peterson, C. F. 1965. Factors influencing egg shell quality. World's Poultry Science 21(2):110-117. (Idaho)

DAIRY PRODUCTS - MARKETING FACILITIES,
EQUIPMENT AND METHODS
Transportation and Facilities Research Division, ARS

Problem. The equipment, work methods, and facilities used by many dairy plants are obsolete and the production per man-hour employed relatively low. A major factor contributing to this obsolescence is the development during the last few years of new types of equipment which can be brought under automatic control. Because of the investment required and the uncertainties of the returns they would obtain, plant operators have been reluctant to shift to automated equipment on a piecemeal basis. They also have been reluctant to build new plants because of a lack of guidelines and criteria on automated plants. However, studies indicate that it is possible in fully-automated plants to increase the productivity of labor 100 percent or more, to improve the qualities of the finished products, and to develop better management-employee relations. Engineering layouts and operating criteria therefore are needed for automated plants to provide guides to plant operators in making the shift from their present equipment and facilities. Most dairy plants lack the technological and engineering skills necessary to plan and develop suitable plant layouts and designs, or to select the types of equipment needed and the controls necessary for full automation. Automated equipment and processes for some types of dairy plants still largely are lacking or are nonexistent. Therefore, engineering research also is needed to develop equipment and processes for automating these plants in order to increase labor productivity and improve product quality.

USDA PROGRAM

The department has a continuing long-term research program involving agricultural engineers and dairy technologists engaged in applied research to develop improved methods, equipment, operating criteria, and plant layouts for dairy plant operators.

Current research covers the development of layouts and operating criteria, based on current technology, for automated dairy product plants. It features the use of remotely controlled air operated valves, electronically-controlled devices, and highly mechanized equipment to facilitate automated processing and CIP cleaning in dairy plants. The work is carried out at Hyattsville, Md., and Columbia, Mo. Work in the Hyattsville, Md., office consists of checking, organizing, and preparing for publication a series of reports prepared under contract. Work at the Columbia, Mo., field location, which is conducted in cooperation with the Missouri Agricultural Experiment Station, consists of collecting, analyzing, and preparing for publication engineering data, from studies in both laboratories and commercial plants, needed for efficient utilization of automated procedures in fluid milk plants.

The Federal effort devoted to research in this area is 1.3 scientific man-years; 1.0 man-year for intramural work and 0.3 man-year for program leadership.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Layouts and Operating Criteria for Automated Dairy Product Plants

At Hyattsville, Md., work was continued on the preparation of a series of contract reports covering the development of layouts and operating criteria for different types of automated dairy product plants. Two of the six contract reports have been published. The status of the work on the four remaining reports in this series is as follows:

1. Plants Manufacturing Ice Cream and Ice Cream Novelties. At the end of the report year this manuscript was at GPO for galley proofs. Results of this research were covered in previous reports.
2. Plants Manufacturing Cottage Cheese, Cream Cheese, and Cultured Milk and Cream. This manuscript was in the hands of the Division Editor at the year's end. Results previously covered.
3. Plants Manufacturing Cheddar Cheese. The contractor's report was prepared for a Department publication during the report year. The significant results of this study were covered in a previous report.
4. Plants Manufacturing Sweet Cream Butter and Dried Nonfat Milk. The contractor's report covering layouts and operating criteria for automated and highly mechanized butter and dried milk products shows that a plant handling 250,000 pounds of milk daily can reduce its labor force from 25 workers to 17 workers and its annual labor costs from \$162,500 to \$110,500. The use of automated equipment and an improved layout makes it possible to increase labor productivity from 1,250 pounds of milk per man-hour to 1,838 pounds per man-hour. The manuscript for a Department publication, based on the contractor's report, was about 30 percent complete at the end of the report year.

B. Increasing Efficiency Through Optimum Utilization of Automation in Fluid Milk Plants

At Columbia, Mo., work on the conversion of the University of Missouri dairy plant to a laboratory for tests and experiments on automation problems was continued. Automated dairy control equipment, purchased during the report year, was received and partially installed in the plant. The following items were operational at the end of the report year:

1. The valving assembly and CIP wash line for the raw milk tanks.

2. CIP tank and control panels (one main control panel and three sub-control panels) for controlling processing and CIP cleaning.
3. The milk level gage and controller for the raw milk tank. The raw milk tank washing cycle was programmed and put into operation. The University installed the electrical controls, air lines, steam lines, and water lines.

The labor requirements and operating procedures for the University's manually operated dairy plant were determined before the automated equipment was installed. At the end of the year these data were being analyzed and the automated system was being checked and modified for maximum operational efficiency.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

None.

LIVESTOCK, MEAT AND WOOL - MARKETING FACILITIES,
EQUIPMENT AND METHODS
Transportation and Facilities Research Division, ARS

Problem. Many of the livestock, meat, and wool marketing, slaughter, and warehouse facilities occupied today are obsolete and the work methods that can be used in such facilities are antiquated. As a consequence, labor costs are excessive and they are increasing. Many firms still are occupying facilities designed primarily for handling rail receipts and rail shipments even though the majority of these products today are moved by motortruck. This situation also adds to handling costs. Numerous firms are occupying "makeshift" facilities which were designed for other uses or for work methods and operations of a bygone era when labor costs were low. Changes in transportation systems, population growths and shifts, and advancements in technology also have brought about changes in the types of facilities--such as livestock auction markets, commercial feedlots, and hotel supply houses. Most private firms handling livestock, meat, and wool lack the technological and engineering skills necessary to plan and develop suitable facility layouts and designs and to select the types of equipment needed. Therefore, engineering and related research is needed to provide guidelines for industry to increase efficiency; including the designing of improved plant layouts, which will provide proper arrangement of work areas to minimize travel distances and excessive handling and the development of work methods that will permit use of mechanized and automated equipment rather than the relatively high-cost manual methods now used in many plants.

USDA PROGRAM

The Department has a continuing long-term marketing research program involving agricultural and industrial engineers, agricultural economists, and meat scientists engaged in both basic and applied research to develop new and improved methods, equipment, processes, and facilities for livestock markets, meatpackers and wholesalers, and wool warehousemen. Livestock market research is carried on at Columbia, Mo., in cooperation with the Missouri Agricultural Experiment Station. Part of this work also is in cooperation with the Central Missouri Livestock Auction, Mexico, Mo. Research on livestock slaughtering and on meatpacking and wholesaling is headquartered at Stillwater, Okla., and is cooperative with the Oklahoma Agricultural Experiment Station. Wool warehouse research will be conducted at the Columbia, Mo., field location.

The Federal effort devoted to research in this area totals 4.7 scientific man-years; 1.4 man-years (1.1 man-year intramural and 0.3 man-year extramural) on livestock; 2.6 man-years (2.0 man-years intramural and 0.6 man-year extramural) on meat; and 0.7 man-year on program leadership. No research is currently being done on wool warehouses.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Automation of Sales Operations on Livestock Markets

Electrically-operated gates, designed and constructed by the Missouri Agricultural Experiment Station under a research cooperative agreement, were installed at the entrance and exit of the sales ring on the Central Missouri Livestock Auction, Mexico, Mo., in August 1965. These gates are operating very satisfactorily, at speeds permitting up to eight sales per minute, and are being used daily in the operation of the market. Two minor problems occurred during the report year. One of the actuating arms on the latching mechanism failed after two months of operation, and was redesigned to correct the weakness. The other problem was the failure of the clutch facing on the torque limiter coupling, because of improper facing material which was supplied with the coupling at the time of purchase. Replacing the facing material corrected this defect. No further problems have been encountered after roughly 700 hours of operation.

Although the operation of the gates on the Mexico market is controlled from the sales arena by the ringmaster or starter, the controls could be located anywhere in the sales arena or in the auctioneer's booth. Livestock market operators have shown considerable interest in these gates and two firms are planning to install electrically-operated gates on their facilities.

At the end of the report year a manuscript covering this research was underway.

B. Automating the Processing of Sales Data on Livestock Markets

Another step in the automation of sales operations on livestock markets will be undertaken under a research cooperative agreement with the Computer Research Center, University of Missouri, Columbia, Mo., to design, assemble, and test an automatic data transmission, processing, and recording system for livestock markets. This agreement, which was approved at the end of the report year is scheduled for completion by December 31, 1967. The Cooperator will determine the types of information and equipment necessary for the system to automatically transmit weights and other coded data from the input station in the auctioneer's box to the market office, process the coded data for each sales transaction, and prepare the necessary records for accounting purposes. Components of the system will be assembled, installed, and tested on the Central Missouri Livestock Auction, Mexico, Mo.

C. Determining Behavioral Patterns of Livestock at Hyattsville, Md.

A manuscript entitled "Feasibility Tests of Selected Stimuli and Devices to Drive Livestock" was completed and published in April 1966. Results of this research were covered in previous progress reports.

D. Development of Mechanical Driving and Penning Device for Livestock Markets

The prototype mechanical driving and penning device for livestock markets, designed and constructed under a research contract, was installed on the Central Missouri Livestock Auction, Mexico, Mo., in July 1965. Problems were immediately encountered with varying voltages on one phase of the three-phase electric service. This and other inadequate design features in the control panel resulted in failure of certain electrical components, which could not be corrected. Other problems were encountered in the timing of each distinct step in the driving and penning sequence. As a result, the system was never able to operate on a continuous basis in the automatic mode. Although the device did work to a limited extent in the manual mode, it could not keep pace with the rapid selling rate on the market. As the contractor was unable to correct these problems, the contract was terminated.

Although the results of this research were not entirely successful, they do provide needed background information which should be useful in future work to increase operational efficiency on livestock markets.

E. Layouts and Work Methods for Wool Warehouses

At Hyattsville, Md., an article entitled "Handling Wool at Lower Costs" was published in the July 1965 issue of Agricultural Marketing. Information in the article was based on research covered in Marketing Research Report 667, "Layouts and Work Methods for Wool Warehouses," published May 1965.

F. Layouts and Work Methods for Hog Slaughtering Plants

At Stillwater, Okla., in cooperation with the Oklahoma Agricultural Experiment Station, a report entitled "Hog Slaughtering and Dressing Systems" was in the publication process. Significant results of the study were covered in last year's report.

G. Layout and Work Methods for Hotel and Restaurant Meat Supply Houses

At Stillwater, Okla., a manuscript entitled "Hotel and Restaurant Meat Purveyors - Custom Service Houses - Improved Methods and Facilities" was in page proof at the end of the report year.

A second manuscript entitled "Hotel and Restaurant Meat Purveyors - Frozen Portion Control Houses - Improved Methods and Facilities" was in the hands of the Division Editor at the end of the fiscal year.

The significant results of the research covered by both manuscripts were reported last year.

H. Handling and Processing "Hot" Pork Carcasses

At Stillwater, Okla., in cooperation with the Oklahoma Agricultural Experiment Station, a study of the feasibility of fabricating, curing, smoking, boning,

and chilling pork cuts from the carcass immediately after slaughter was completed. The data show that it is feasible to cut the pork carcass prior to conventional chilling. The fresh cuts can be formed, shaped, or made to look similar to the conventional processed products. Ham can be boned, cured, shaped, and processed to a finished form prior to the initial chilling. The data indicate no significant differences from conventionally processed pork from a quality standpoint. The color studies show no significant differences in color retention properties of hot processed and conventionally processed hams. At the end of the fiscal year, tests had just been completed to determine optimum times, temperatures, and velocities to quick chill each pork cut. This data is being analyzed and interpreted for use in designing a conveyORIZED quick chill cabinet to be installed in a pilot "hot pork processing" line.

I. Layouts and Work Methods for Small Inedible Rendering Plants

At Stillwater, Okla., field work continued on research to develop more efficient work methods, equipment, and facilities for small inedible animal fats renderers. Tentative results indicate that continuous-type rendering processes (as manufactured today) have little application to the small renderer. These processes have been designed almost exclusively for large operations. From an efficiency standpoint, it appears that most of the industry problems affecting this area evolve from the lack of sanitation controls. Application of continuous rendering processes to larger renderers can improve this situation. Small renderers appear to be faced with the necessity of applying more rigid controls in clean-up and sanitary handling of raw and finished product.

Few renderers today apply sanitary practices in their plants, probably because of the lack of regular or rigid inspection by outside agencies of their facilities.

Work is now underway to prepare a report to compare the relative efficiencies involved in utilizing an expeller or hydraulic press in a small two-cooker type batch operation.

J. Layouts and Work Methods for Beef and Veal Boning Lines

At Stillwater, Okla., data to determine more efficient work methods, equipment and layouts for beef and veal boning lines is well underway. Data from field studies have been compiled on labor requirements, methods' and equipment costs for both mechanized and manual handling of meat, bones, and fat. At the end of the fiscal year, these data were being analyzed.

K. Methods, Equipment and Facilities for Specialty Meat Plants

At Stillwater, Okla., work was initiated to improve the operational efficiency of smoked and cured specialty meat processing plants by developing improved work methods, equipment, and facility layouts for receiving, handling,

packaging, storing, and loading out specialty meat products. Work has not progressed sufficiently to report research results on this project.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Layouts and Work Methods for Wool Warehouses

Webb, Tarvin F., and Bolt, Charles D. 1965. Handling Wool at Lower Costs. Agricultural Marketing, Vol. 10, No. 7, July 1965.

Determining Behavioral Patterns of Livestock

Webb, Tarvin F. 1966. Feasibility Tests of Selected Stimuli and Devices to Drive Livestock. ARS 52-11, 20 pp.

Automation of Sales Operations on Livestock Markets

Webb, Tarvin F. 1966. Automation of Sales and Yarding Operations on Livestock Markets. Paper at the Annual Meeting of the American Stockyards Association, Washington, D. C., June 21-24, 1966.

POULTRY AND EGGS - MARKETING FACILITIES,
EQUIPMENT AND METHODS
Transportation and Facilities Research Division, ARS

Problem. Continuing increases in the production of meat classes of poultry and the rapidly developing demand for further processed poultry meat items has resulted in significant changes in the processing procedures and requirements for marketing poultry. Similarly the increase in the number of large scale commercial farms producing large lots of uniform fine quality eggs has called for drastic changes in the preparation of eggs and egg products for market. These changes have had an impact on the poultry processing and egg grading and packing plant operations throughout the country, especially as these are related to facilities, equipment and work methods. In adjusting to these changes industry has tried in many cases to work out the problems involved on an individual plant basis. In the main, the changes effected, furnished only temporary relief in the area of plant expansion needs and were of little help in developing guidelines for new plants or solving general plant production problems and problems involving new processes. The research that the Department has undertaken in this area has been successful in developing some of the basic guidelines that industry needs and that are now being used effectively by many plant operators. However, in order to continue to improve operating efficiency in existing facilities, and be in a position to provide effective assistance in planning new or expanded facilities needed in connection with many of the recent food processing and marketing trends; develop plant layouts, devices, and equipment, and efficient work methods for the handling, processing, grading, and packing poultry, eggs and egg products in this changing environment; this research effort needs to be continued and expanded.

USDA PROGRAM

The Department has a continuing long-term program involving engineers and marketing research analysts engaged in both basic and applied research to develop more efficient work methods, techniques, operating procedures, devices, and equipment and to design improved facilities for the handling and preparation for market of poultry, eggs, and egg products. Research on chicken-class poultry processing operations is carried on in commercial poultry processing plants in the Southeast by Department personnel at Athens, Ga., in cooperation with the College of Agriculture Experiment Stations, University of Georgia. Contract research to determine the optimum production rates in chicken processing plants for the eviscerating and federal post-mortem inspection operations, conducted by the American Scientific Corporation, Alexandria, Va., in selected poultry processing plants on the Delmarva Peninsula, was completed during the report year. Research on turkey-class poultry processing, egg products processing, and cleaning, grading, and packing shell eggs is carried on in West Coast turkey processing and in egg grading and packing plants, in cooperation with the California Agricultural

Experiment Station at Davis. Contract research to design, construct and test a mechanized turkey deboning line to increase worker productivity and maximize the yield of prime deboned meat cuts was initiated with the Gordon Johnson Company, Kansas City, Mo., at the close of the report year.

The Federal effort devoted to research and development work in this area during the Fiscal Year 1966 totaled 4.1 scientific man-years of which 2.0 man-years (including 0.3 man-year of contract work and 0.2 man-year under a cooperative agreement with the University of Georgia) is devoted to poultry; 1.1 man-years (including 0.4 man-year under a cooperative agreement with the University of California) to shell eggs and egg products; and 1.0 man-year to program leadership.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Methods, Equipment, and Facilities for Grading and Packing Eggs

This research completed in Hyattsville, Md., was directed toward reducing egg marketing costs through research involving a systems analysis of existing work methods, equipment, and facilities for grading and packing eggs, and the development of improvements. A report on the results of this study; "Evaluation of Mechanized Egg Grading and Packing Equipment" was ready for publication at the end of the report year. It will provide guidelines for egg grading plant operators in determining the degree of mechanization that should be most efficient in their respective operations and in selecting the combinations of mechanized egg grading and packing equipment that will yield the greatest output per worker and equipment dollar at specified production and product quality levels.

B. Improved Methods, Techniques and Equipment for Cleaning Eggs

This research, conducted at Davis, Calif., involves the development of techniques and equipment that will do an effective in-line job of cleaning shell eggs with minimum quality deterioration and breakage, and that will minimize labor requirements. The basic studies of typical spoilage organisms to determine time and temperature conditions necessary for safe, commercial egg washing; the testing of commercial washers; and the results of laboratory tests of an experimental washer that was designed, constructed and tested under research contract; were published in a Marketing Research Report; "The Bacteriological, Chemical and Physical Requirements for Commercial Egg Cleaning". The report shows that by applying the time and temperature parameters determined in the laboratory and by using some of, and by improving or adding to the cleaning mechanics of commercial machines, almost 70 percent more eggs can be cleaned with less hazard to egg breakage and spoilage than is now being done in commercial operations.

The results of the field tests of the experimental cleaner, conducted in a commercial egg grading and packing plant under regular operating conditions, prepared in manuscript form were edited and ready for publication at the end of the report year. The report shows that the cleaning effectiveness of the experimental equipment, under commercial conditions, averaged 78 percent as compared to an average of 35.9 percent for commercial units. Shell damage due to cleaning action was reduced by almost 50 percent (to 1.89 percent checks). Spoilage, after holding for an extended period, was essentially eliminated (0.6 percent).

C. Improved Layouts and Engineering Designs for Egg Grading and Packing Plants

This long-term research carried on at Davis, Calif., is directed toward the development of improved building design and layouts for small egg grading and packing plants involving preparation of engineering design drawings, the development of building specifications, and facility and equipment layouts. The recent trend in the poultry industry indicates a need for small efficient egg grading and packing plants where the production of a few large commercial flocks are handled on one of the farms. This trend has given rise to a need for information on plant facilities including equipment arrangements, storage space requirements, egg cooling facilities, and structural design guidelines. The average operator of a small plant, generally has started operations in a small facility and then as flock and size production increased, the plant capacity has been expanded. This situation has created a need for layouts which are planned for expansion.

To provide a basis for designing improved facilities; the overall layout, equipment arrangement, space allotted to each functional area, and the site plan of a number of commercial processing plants within the desired size range have been studied and evaluated. From these studies, the basic space requirements for dry (packing materials) storage, cold storage, grading and packing area, and the building site have been developed. These data have been used to prepare layouts for use with any of the more popular egg grading and packing equipment suitable for this volume level. These layouts have been "tested" by use of plastic templates cut to scale so that the equipment operating characteristics could be carefully considered and efficient arrangement assured. Building specifications to meet floor space, ceiling height, and floor load requirements have been completed.

D. Development of Equipment and Methods for Pasteurizing Liquid Whole Egg in Small-Volume Breaking Rooms

This research, which is carried out under a research cooperative agreement by the University of California's Department of Food Science and Technology, is part of a long range program at Davis, Calif. It is designed to develop pasteurizing equipment that will meet the needs of small egg grading and packing plants that have found it advantageous to break out and freeze undergrade eggs, instead of marketing them in the shell at a considerable

loss. With recent requirements calling for the pasteurization of liquid eggs by both State and Federal authorities, an urgent need has arisen for equipment that can handle the production of these small-volume operators as effectively as pasteurizing equipment presently employed in large-volume plants.

Under this project studies have been made of the use of pasteurization by the batch method (because of its adaptability to handling small quantities of liquid) through a balance between time and temperature parameters that will provide pasteurization (microbial kill) without damage to the functional properties of the egg liquid and to determine the feasibility of designing equipment for operation under varying conditions of product volume and temperature. An experimental vat was used for heating and cooling egg liquid and checked against the results from laboratory apparatus to establish the time requirements for both heating and cooling under various conditions. Tests of the effect on the functional properties checked against theoretical thermal death time and temperature for bacteria that could be involved, indicate that the process is feasible.

Studies to verify thermal death rates for bacteria during actual operations are planned. From these data and from the earlier results the specifications for a prototype batch pasteurization unit for laboratory and commercial testing will be developed.

E. Improved Methods and Equipment for Cutting Up and Packing Chickens

This research, conducted at Athens, Ga., involves a study of the methods, equipment, and facilities for cutting up whole ready-to-cook chicken. Research on the mechanized weighing and packing of chicken parts, "Mechanized Weighing and Packing of Broiler Parts to Exact Weights", was published early in the report year. It shows that mechanized weighing equipment can reduce labor requirements 35 percent as compared with requirements for manual methods and minimize the losses due to overweight packages. However adaptability to commercial operations will require large-scale operations where a wide weight range of chicken parts will be available.

Observations during the earlier phases of this research disclosed a wide variation in methods and equipment employed in the chicken "cut-up" operation; emphasizing a need for developing more efficient methods and equipment for performing the basic dismembering cuts in accordance with the U.S. Department of Agriculture standards of identity for chicken parts.

Work during the past year involved time and motion studies of chicken dismembering operations in a number of selected case study plants in Georgia and North Carolina. Plants were selected to reflect the wide range of operating techniques in high volume production "further processing" plants, as well as those employed on small cut-up lines in plants that are primarily packaging whole ice-packed birds. Most of the operations were performed on a mass production line where each operator dismembered one part from the carcass.

Other plants were studied where more than one cut was made at each work station, and one was found where the entire carcass was cut into parts at each work station. In all, 50 cut-up operations were filmed for time and motion study. The film was analyzed and time values were established for each significant technique found for cutting up or dismembering chickens in accordance with USDA standards.

Preliminary analysis indicates that much labor in further processing areas could be saved by improvements made through modification of existing equipment or by the design and fabrication of new equipment items that would mechanize these operations more fully. A complete analysis of the time-study data for various cut-up operating techniques will serve as a basis for developing labor requirements and work station layouts and for designing efficient cut-up lines for selected levels of production.

F. Improved Designs for Chicken Processing Plants

This research at Athens, Ga., involving the development of improved plant designs and layouts of chicken processing plants, has been completed. A revision of the manuscript draft is now being coordinated with the cooperators. When published the report will furnish guidelines for plant site selection and building design. Guidelines for an efficient layout for a 4,800 bird-per-hour plant and its expansion to a 9,600 bird-per-hour plant are set forth and illustrated. Factors concerning location of facilities auxiliary to the main processing operations and critical to economic expansion are explained and illustrated.

G. Improved Methods, Equipment and Facilities for Improving Chicken Processing Plant Efficiency Through Balance of Inspection and Eviscerating Operations

This research was carried out under a contract with the American Scientific Corporation, Alexandria, Va., in selected plants on the Delmarva Peninsula. Inspector combinations and equipment design and arrangements were studied to evaluate the processing and inspection labor and equipment requirements that yield the most efficient plant worker-inspector mix for plants processing 1,000 to 3,000 birds per hour, 3,000 to 5,500 birds per hour and 5,500 to 8,000 birds per hour. Optimum line speeds; that is levels at which maximum production per plant worker and utilization of inspectors' time is possible, were predicted from the data derived from time and motion studies. The predictions were tested under operating conditions.

The most significant findings are: (1) One inspector per line can properly examine more birds per man-minute when he inspects each bird passing his station and when the birds are suspended on 12-inch centers than by other methods tested. Obviously, this was due, in part, to the elimination of the "search" element. The work also was easier because better visual inspection of the carcass exterior was possible than when birds were hung closer together, as is the case when two inspectors inspect every other bird or

three inspectors examine every third bird spaced 6 inches between carcasses, and (2) federal inspection labor and eviscerating labor utilization peak at about the same point.

A report on the results of the study is being prepared by Department personnel which will set forth guidelines for economical operation of poultry eviscerating lines at various production levels for different types of equipment and line types. The report will present layout criteria for federal inspection stations and list manpower requirements for various production levels to provide the best balance between inspection and eviscerating personnel. It should be useful in the administration of the federal poultry inspection program in assigning manpower to processing plants and to processors as a guide to operating levels that maximize labor input and in selection of equipment.

H. Improved Methods and Equipment for Handling Live Chickens by Commercial Processing Plants

This research, headquartered at Athens, Ga., involves studies of live chicken handling operations to determine the causes of the relatively high rate (15 to 20 percent) of bruising of live chickens prior to slaughter and to develop improvements that will reduce this costly damage to product quality with minimum additional cost.

During the report year evaluation of live chicken handling operations to determine labor requirements and locate areas or operations where down grade bruising occurs were carried out in typical commercial facilities in Georgia, North Carolina, and Virginia. The studies included: (1) Methods analysis of catching operations to determine labor inputs for driving, catching, cooping, and receiving chickens; (2) sampling of flocks prior to catching and cooping operations to determine the extent of bruising caused by production management practices; (3) developing a control system for sampling and recording data on individual flocks; (4) training researchers to distinguish between acceptable and non-acceptable blemishes on chicken carcasses and to be consistent in tabulating downgrading bruises in keeping with USDA requirements; and (5) designing experiments for determining the extent of bruising occurring while preparing broiler houses for catching, driving, and cooping birds, when transporting them to the processing plant, and during unloading and hanging on the processing line at the plant.

Preliminary findings indicate that: (1) Frequently a relatively high degree of bruises exist prior to catching and cooping; (2) larger coop doors can reduce the bruise level; (3) the use of a portable light weight truck loading ramp (in lieu of stacks of empty coops) for the live handlers reduces loading time, and coop damage; and (4) the "G" force that cooped birds are exposed to during transport to the plant is insufficient to cause significant bruising.

Devices developed and tested to improve methods and equipment for loading and handling live chickens include: (1) Modification of a chicken coop door to provide an adjustable opening which is larger than a standard coop door;

(2) a control system for tabulating downgraded carcasses on the processing line whereby a switch actuated at the inspection station tabulates the entry on a remotely located counter; and (3) a plywood ramp for crews to mount the truck when loading live chickens.

Basic research into the reaction of poultry when subjected to various external stimuli was conducted by the Poultry Division of the University of Georgia under cooperative agreement with the Department to determine the feasibility in employing stimuli reactions helpful to gentle efficient live handling during catching and cooping. Thus far the results in this direction have been negative. However some of the results from the "light stimuli studies" indicate that the quieting effect of certain lighting combinations may be helpful in reducing bruises during rearing of occasional "wild" flocks.

I. Improved Methods and Facilities for Chilling, Weighing and Packing Turkeys

The field studies for this research, conducted at Davis, Calif., covering the development of improved methods and equipment for weighing and packing turkeys was completed during the report year, and a manuscript setting forth the results has been prepared in draft form.

This research was directed at reducing the relatively high labor requirements for packing whole eviscerated turkeys and synchronizing and balancing these operations with the processing steps that precede them. Weighing and bagging station equipment designed, constructed, shop tested, and operated for brief commercial runs was redesigned and tested extensively in a commercial plant. Time and motion study evaluations were made of the operators using this equipment to determine the labor requirements. Results were compared with the labor requirements for existing methods of weighing and bagging determined earlier in the study. Production rates and labor requirements for various combinations of existing methods and the experimental method were developed. A comparison shows that for a two-scale type bagging line, the required labor can be reduced 14.9 percent when using the improved equipment. This means that in an operation which normally packs 10,000 hen turkeys per day the crew size can be reduced by one worker. The results of these studies will be prepared in final report form and published during the next report year.

J. Improved Methods, Equipment and Facilities for Preparing Turkey Specialty Items

This research, carried out at Davis, Calif., is directed towards the development of improved methods, equipment, and facilities for processing many of the speciality items currently being prepared from whole ready-to-cook turkeys. The sharp increase in the production of turkey speciality items prepared from deboned turkeys (during the first 3 months in 1966 over 20 million more pounds of turkey were further processed than during the same period in 1965), has greatly increased the need for improved efficiency in deboning. Because of the many variations in methods for performing these

operations, the low return type investment for equipment manufacturers and the secrecy maintained by plant managers, there has been a lag in the development of improved methods and equipment in this processing area. This research therefore is directed towards a systems engineering analysis of turkey carcass dismembering and deboning operations. Emphasis is being placed on: (1) The development of improved methods for presenting carcasses for deboning; (2) improved labor efficiency and meat yield in deboning; and (3) improved tools and devices for removing meat from the carcass.

During the report year time and motion studies of typical deboning operations were continued and the experimental testing of air powered knives for carcass dismembering and deboning was initiated. Plants in the major turkey production areas in the U.S. were visited to verify deboning practices followed in selected case study plants and to acquire background information for preparing specifications for a research contract covering the development of a mechanized turkey deboning line to reduce the labor requirements and increase the yield of prime cuts of deboned turkey meat. The specifications for a research contract were prepared and the contract was negotiated near the end of the report year. No work was initiated by the contractor during the year. By providing mechanical holding, positioning and transport of individual carcasses; faster, less fatiguing and more accurate cutting should be possible. After design, construction, and trial tests; production rates and prime meat yields achieved on the experimental line will be obtained and compared with the same factors in existing operations. As the research under contract proceeds, evaluation of labor and equipment requirements for current deboning operations will be completed and tests with new or improved hand or powered cutting tools and devices will be continued with existing deboning operations.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Improved Methods, Techniques and Equipment for Cleaning Eggs

Hamann, J. A. 1965. U. S. Department of Agriculture Research in Egg Cleaning Equipment. A technical paper presented at the Annual Florida Poultry Institute, Camp McQuarrie, Ocala National Forest, Fla., August 1965.

Hamann, J. A. 1966. Washing Eggs Clean with Minimum Damage or Danger of Contamination. A technical paper presented at the Egg Processor's Short Course, University of Iowa, Ames, Iowa, Jan. 1966.

Walters, R. E. 1966. New Design Features for Egg Washers. A Technical Paper presented at the 38th Rural Electric Conference, University of California, Davis, Calif., Feb. 1966.

Brant, A. W., Starr, P. B., and Hamann, J. A. 1966. The Bacteriological, Chemical and Physical Requirements for Commercial Egg Cleaning. Marketing Research Report No. 740, April 1966.

Improved Layouts and Engineering Designs for Egg Grading and Packing Plants

Walters, R. E. 1966. Production Efficiency for Modern Egg Processing Plants. A technical paper presented at the University of California Egg Quality School, Riverside, Calif., May 1966.

Improved Methods and Equipment for Cutting Up and Packing Chickens

Childs, R. E., and Walters, R. E. 1965. Mechanized Weighing and Packing of Broiler Parts to Exact Weights. Marketing Research Report No. 700, July 1965.

Improved Methods and Equipment for Handling Live Chickens by Commercial Processing Plants

Childs, R. E., and Shackelford, A. D. 1965. An Engineering Analysis of Methods of Handling Live Poultry Prior to Slaughter. A technical paper presented at the 54th Annual Meeting of the Poultry Science Association, Athens, Ga., August 1965.

ECONOMICS OF MARKETING
Marketing Economics Division, ERS

Problem: With the changing nature and structure of agriculture, the capacity to adjust and cope with the dynamics of modern marketing is required increasingly of producers and distributors. Without a continual flow of objective information based on research upon which to make intelligent decisions in adjusting to change, the efficiency of the marketing system can be greatly impaired resulting in higher costs of moving the Nation's output of food and fiber from the farm to the consumer. Not only are structural changes occurring but likewise changes in institutions are taking place along with the redirection of public policies and programs shifting the economic environment in which all concerned with marketing must perform and operate.

Of continuing concern in the area of development of markets is how to strengthen markets for farm products faced with a continuing rise in distribution costs and increasing competition from synthetics and substitutes for agricultural products. Farm groups continue to spend at record levels for advertising, promotion, and merchandising in seeking to expand the sales of their respective farm commodities. Despite the magnitude of these expenditures by farm groups, only limited, quantitative information is available by which to appraise the role or influence of such activities on sales as well as returns to producers. Because of increasing complexity of marketing and its diverse but interrelated aspects, firms producing and distributing farm products need more information on demand creation upon which to base marketing decisions as well as improved techniques for decision-making.

USDA AND COOPERATIVE PROGRAMS

The Department has a continuing long-range program of economic research directed in two major areas: (1) Organization and performance of markets, and (2) development of markets. Research on organization and performance is designed to increase the efficiency of marketing and assist producers and marketing agencies in adapting to a changing environment. Research is conducted on a wide range of functional and commodity problems that arise in moving farm products from producers to consumers. The program involves both basic and applied research and is primarily oriented to problems of national and regional scope. Field studies are often conducted jointly with State Agricultural Experiment Stations, with processors and distributors of agricultural products, transportation agencies, and agriculturally-oriented trade groups. Producer groups and trade organizations have, with increasing frequency, made financial contributions to the division research efforts.

On a functional basis the Federal research effort on organization and performance of markets pertaining to animal-poultry and products involves the following scientific man-years: Market institution and market power, 12.1; prices, margins, and costs, 16.6; and location and interregional competition, 6.9.

Research on the development of markets pertaining to new products and services involves 2.5 man-years.

For both program areas referred to above, on a commodity basis the man-years of research effort involve: dairy, 8.5; poultry, 16.2; livestock, 12.3; and wool, 0.6.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Organization and Performance of Markets

1. Market Institutions and Market Power

Changes in the structure of marketing agricultural products directly affect the bargaining strength of buyers and sellers. In turn, these changes have a direct bearing on marketing practices, services and prices, and ultimately on producers, marketing firms, and consumers. The number, sizes and types of firms, and the potential ease of entry into the industry by new firms affects the competitive environment in which each operates.

There is a tendency for business in the fields of the food industry to become more concentrated. An exception to this general trend is in the area of meatpacking where concentration has decreased. In neither food processing nor in distribution do economies of operation resulting from large size require substantial concentration in national markets.

Concentration of purchasing power by retailers in the food industry is especially significant. Today market power has been transferred from food processors and manufacturers to retailers. It is anticipated that developments in the industry are likely to further enhance the position of retailers. The source of the retailer's market power is through his regular contact with consumers. The retailer controls the products he buys and those he stocks for consumers to purchase. In effect, he is the buying agent for a large number of consumers. Because of the great output by the agricultural industry and food processing firms, an abundance of products places the retailer in a strong bargaining position.

Concentration has increased at a fast pace since 1950 in the food manufacturing industry. Concentration of both value added and assets increased about 1 percent per year. Moreover, concentration of profits has increased even faster. The increase in concentration is primarily a result of mergers and acquisitions by large firms of important independent manufacturers. The immediate action of the acquiring firm is to enlarge advertising outlays for new products. This action further tends to seal off new competition.

Unorganized farmers have little or no positive market power. In turn, they must depend upon competition among the buyers of their products to obtain the value that market conditions justify. When raw farm products are sold to buyers in local market who are few in number, there is always danger that competition may not be sufficient and thus not effective in achieving a fair return to the producer.

Selected studies are reported upon relating to changes in market institutions and market power. A brief summary of some of the more important findings is given.

Poultry and Eggs

Major marketing channels for poultry and egg products have become more direct from the processor to the retailer, bypassing the wholesaler-distributor agency. Improvements in plant operating efficiency, fewer and larger producing units and input supplying and marketing firms, improved quality, higher density of production, and greater coordination of various functions have also helped reduce costs. A continuation of current trends is indicated for the future. As a result of an even higher degree of coordination of poultry production and marketing functions, there is likely to be increased price stability, the production of standardized products for specific markets, a further lowering of costs, and growing importance of multi-plant and multi-function firms. Realization of economies of scale and better utilization of plant capacity will further reduce processing costs and result in larger-sized units and fewer plants. Production density will be increased further resulting in reduced assembly costs.

Many retailers have delegated grading and cartoning functions for eggs to others, such as assembler-distributors. The choice of procurement systems is related to local surplus-deficit conditions, area producing and marketing structures, and overall retail firm policies. Problems exist relative to the certainty of regular purchases from suppliers by retailers, the disposal of surplus eggs by suppliers or retailers, and the ability to obtain required supplies of various grades and sizes.

In studies of the Georgia egg industry, vertically integrated production and marketing operations appear to have many advantages over non-integrated operations. Integrated firms were able to reduce seasonality of supplies and lower production and marketing costs. Net returns to producers in various segments of the marketing system were not significantly different, except in the larger owner-integrated operations where the return was 2 to 3 cents more per dozen.

The role of the poultry producer has changed materially with the shift to a highly-integrated industry structure. One indication has been the expansion of contract production. For example, more turkeys are being grown under risk-sharing contracts, primarily with feed firms. More firms are producing turkeys on company-owned or leased farms. About 20-25 percent of turkey producers secure credit from banks and other similar sources. Production financed by feed companies and other amounts to 45 percent. Risk-sharing production is 25 percent and company production 10-15 percent. These percentages overlap to some extent and are not completely additive.

Contract grower returns were compared with those of an independent grower for turkeys and eggs. Changes in the price paid for feed and changes in the price received for the turkeys or eggs had a much more pronounced effect on returns to the independent than the contract grower.

Over time, the contracts for broilers, turkeys, and eggs have tended to guarantee the grower a minimum fixed return and there is less opportunity now for the contract grower to share in increased profits as product prices increase or the price of inputs decreases. Contracts now guarantee a return that will vary in a relatively narrow range for a given contract although there may be a wide variation between grower returns under different contracts.

While poultry meat has long been used in the production of soups and canned meat, pies, dinners, and many new products have increased in importance in recent years. Currently, cooked parts, dinners, rolls, canned boned meat, and gourmet and specialty items are the major further-processed products made from young chicken meat. For mature chicken meat, soups, canned boned meat, pies, and canned whole chicken are the major end-products. Turkey meat is used mainly in rolls, roasts, dinners, pies, and sliced and prepared meats. Large plants produce the bulk of most items except for specialty and gourmet items, prepared meats, and foreign food preparations. Eight percent of the plants handle over 70 percent of the poultry meat used in further-processing. Economies of scale exist in further-processing and may cause plant numbers to eventually decline.

Livestock

Between World War I and II, meatpacking plants in the livestock producing areas became increasingly important. In the mid-fifties many large, full-line plants located at terminal markets were closed as slaughter shifted even nearer to livestock production areas.

Changing size characteristics of firms in the slaughter industry also have an impact on livestock marketing. Data for the federally inspected sector of the industry show an increasing number of firms with decreasing variation

in size. Concentration of slaughter in the hands of a few large firms has declined. In 1950, the 4 largest firms slaughtered 51 percent of the federally inspected production. By 1964, their share had dropped to 33 percent.

The vast terminal markets that once handled nearly every livestock sale now operate at part capacity in many cases and have disappeared altogether in others. Packers buy most livestock directly from farmers and move them to specialized, highly efficient plants nearby. The meatpacking industry has increasingly been characterized by fast-growing, highly specialized firms, small by the standards of the largest packers who once dominated the industry (and have seen their share of the livestock slaughter gradually but steadily diminish in recent years). These packers typically use Federal grade and other specifications to sell a highly uniform product to very large retail firms in great quantity.

Livestock marketing today appears to be nearing a shift to substantially more objective methods of quality appraisal. A steady trend toward selling livestock on the basis of carcass weight and quality has been observed for several years. The development of a widely accepted and used system of selling slaughter livestock on a carcass basis may be the key to the development of an advanced livestock marketing system that will not only take the guesswork out of buying and selling slaughter livestock but will reduce transportation cost and increase competition at the same time.

Dairy Products

The number of fluid milk bottling plants (excluding producer-dealers) in the United States declined 53 percent between 1948 and January 1965. The number of plants declined at a slightly faster rate in 82 Federal order market areas (excluding New York-New Jersey). Between 1950 and 1964, the number of pool handlers in these markets declined 57 percent. Most of the plants that went out of business were small. Some small plants increased their volume by installing new equipment or by fuller utilization of capacity. The following distribution of plants by annual volume shows that plants bottling less than 5 million quarts of milk a year declined from 93 percent of the total in 1950 to 64 percent in 1964:

<u>Annual volume per plant</u> <u>Million quarts</u>	<u>1950</u> <u>Percent</u>	<u>1964</u> <u>Percent</u>
Under 1	72	28
1 - 4.9	21	36
5 - 9.9	4	13
10 or more	<u>3</u>	<u>23</u>
Total	100	100

The number of plants manufacturing dairy products has fallen somewhat less rapidly than fluid milk plants. Between 1944 and 1961, this type declined 37 percent. (These are the only years for which data on the total number of plants manufacturing dairy products are available.) Between 1944 and 1964, the number of plants making butter, cheese, evaporated milk, and ice cream declined more than half. Plants producing creamed cottage cheese and nonfat dry milk declined somewhat less as production of these products increased more rapidly than many others.

The number of large plants manufacturing dairy products has increased. In 1944, 122 plants produced at least 2 million pounds of butter per year. In 1963, 219 plants were in this size category. During this period, the number of smaller plants declined from about 3,900 to about 1,100. The smaller plants accounted for 74 percent of the butter output in 1944 and 38 percent in 1961.

The direction of change in American cheese plants generally was similar to that of manufacturing other dairy products. In 1944, 155 plants were producing 1 million pounds of cheese or more per year. By 1963, there were only 431 such large plants. At the same time, the number of small plants declined from about 2,000 to 600. The small plants accounted for 70 percent of the production in 1944 and 38 percent in 1961.

Wool

Major changes in the structure, location, and practices of the textile industry have had a definite impact on the marketing requirements of domestic grease wool; but lack of information relating to these recent significant changes has hindered efforts by growers and marketing agencies to properly adjust their marketing practices. As a result, the cost of marketing raw wool often amounts to as much as 30 percent of the producer's income from wool. An evaluation of the entire wool marketing system (producers, warehouses, local pools, and textile firms) is near completion. Recommendations are being developed to improve the system, along with suggested means of implementation. The American Farm Bureau Federation and National Wool Marketing Corporation are cooperating in the study.

2. Prices, Margins, and Costs

It is not possible to ascertain whether the price spread for a particular product is economically justified by examining only the amount of the spread. Even breaking price spreads into their component parts is only a limited step toward appraising them. The National Commission on Food Marketing concluded that "Price spreads can be used as a starting point for evaluating the food industry's performance if the following questions are asked: (a) Are the functions for which marketing costs are incurred necessary ones? (b) Are the functions efficiently performed? (c) Are profits reasonable? If the answer to each case is yes, then the price spread is justified.

Farm-retail spreads have widened in the past year. The rising cost of labor and other inputs that marketing firms purchase have contributed materially to the widening spread. Continuing evidence substantiates that a low correlation exists between short-run changes and farm-retail spreads for individual products and the actual costs of performing marketing services.

Rising prices of food during the past year, particularly pork and milk, have brought an avalanche of requests as to the reasons underlying the upward movement. Higher prices at the farm level for many food products along with increased marketing charges have contributed to higher prices paid by consumers. Much staff time was utilized in developing special information on spreads and prices and relaying this to persons and agencies requesting it. The spread between the retail cost and farm value of the farm food market basket was about 3 percent wider in July-September 1966 than in July-September 1965. Cost of materials, labor, and other goods and services have risen at a faster rate in recent months than previously during the 1960's; this contributed to the increase in farm-retail spreads. Improvements in efficiency have continued to offset in part the rise in these costs.

Labor cost and output estimates show that improvements in output per man-hour have limited the increase in labor cost per unit of product marketed to 9 percent since 1957-59, although labor cost per hour was up 30 percent.

Prices farmers received for the foods in the market basket averaged about 8 percent higher in the third quarter of 1966 than a year earlier. All product groups in the market basket rose.

Poultry and Eggs

Analyses of the costs of hatching chicks and poults and of the possible economies of scale provide guidelines for management to use in increasing the efficiency of hatchery operations. In-hatchery costs per salable pullet hatched ranged from 9.1 to 25.9 cents in the 24 surveyed egg-type chick hatcheries. Wide variations were found in utilization of labor, incubator capacity, length of hatching season, rate of hatchability and managerial efficiency. In the six model hatcheries synthesized in this study (1 to 10 million eggs a year at full capacity), the in-plant costs per salable pullet ranged from 4.8 to 23.0 cents depending on the hatchery size and capacity utilized.

Farm-to-retail price spreads for fowl are 5-8 cents wider than on frying chickens. Further-processed poultry products are generally priced by plants on an administered pricing basis and retail markups are generally 20-25 percent.

The per pound cost of assembling live turkey increases with the rise in firm size and decreases with an increase in density (pounds available per square mile). Excluding costs for shrinkage, costs for a firm handling less than

5 million pounds per year ranges from just over 0.20 cent per pound for high density to about 0.35 cent per pound for low density. The costs of a firm handling 70 million pound ranges, respectively, from 0.25 cent per pound with high density to almost 0.5 per pound with low density. Labor costs account for over 60 percent of total costs of assembly.

Egg grading and packing plants in 1970 will be operating at very nearly the same overall level of costs per dozen eggs as at present, but costs may be somewhat higher by 1975. The relationships between costs of firms of varying sizes may change somewhat, economies of scale becoming a more important factor than in the past.

Structural changes in egg markets have created a need for ways to improve the present pricing system or find workable alternatives to assure fair prices to buyers and sellers at various trading levels. Main problems in using base price quotations are: (1) the tendency of many firms to use the base without playing an active role in determining it; (2) the lack of agreement between base-price-producing markets and outlying areas on supply and demand conditions and values; (3) thinness of trading on mercantile exchanges; and, (4) the failure of base prices to represent the kinds of eggs moving in greatest volume in trade channels. However, the base price quotation system is widely used and accepted in the trade and is an efficient means of arriving at values. Thus, possible improvements of alternative systems should preserve these desirable features while correcting existing deficiencies.

Despite the increased importance of egg quality-control programs, variation in quality of individual producers remains substantial. This suggests the need for stricter enforcement of programs or their adjustment to more appropriate standards. Egg quality averages substantially lower for very small flocks than for medium-sized and large flocks. Along with quality control a great need is towards increasing the number of cases per lot. This saving in "down time" from small lots will substantially increase the number of cases processed per hour and thereby decrease the cost of each dozen of eggs packed.

Livestock

A survey of 20 representative meatpackers in most major livestock centers showed delivery costs averaged 89.3 cents per hundredweight for 150-miles haul in August and 83.9 cents per hundredweight for 220-miles haul in February for average loads. These figures represent averages for nearly 3½ million pounds of meat. For individual firms, delivery costs for all meats averaged from as low as 11 cents per hundredweight to as high as \$3.97 per hundredweight. Costs were higher for smaller average loads and shorter average hauls, but were also quite variable among firms for similar

loads and mileages. Driver cost amounted to about two-fifths to one-half of delivery cost; and driver man-hours showed wide variation among routes of similar loads and mileage. Many packers could reduce delivery costs up to 50 percent with estimated savings in the range from 70 cents to \$1.00 per hundredweight.

The adequacy of price information on livestock and meat in a changing market environment is a continuing question. Price information on dressed beef available to users in the South reflects prices from non-Southern markets and does not appear to be adequate for decision-making by meat handling and livestock producing firms in the South. Available price information is generally not adequate for much of the relatively light beef carcasses produced in Texas and Oklahoma. In addition, available price information for much of the heavier beef is based on pricing trends in more distant markets which often is not representative of supply and demand conditions in the Southern Plains. The availability of current and accurate price information for designated major markets in Texas and Oklahoma can contribute to continued growth, orderly marketing and a viably competitive livestock and meat industry in the Southern Plains.

Dairy Products

With excess capacity in the industry, what are alternatives available to milk manufacturing plants to utilize all facilities without increasing costs? The economic feasibility of operating a flexible dairy manufacturing plant with facilities for producing either butter or cheese and their associated by-products appears questionable, based on a study made of Minnesota plants. This conclusion is based on net returns for model dairy plant. During 1959-64, it would have been more profitable to process milk in the standard butter-powder plant most of the time rather than in the flexible plant.

The annual average daily receipts of whole milk in Minnesota dairy manufacturing plants is about 75 percent of the peak day receipts. Milk dryers are more fully utilized during a 24-hour period than butter churns or cheese vats. In very large butter-powder plants, dryers are used about 20 hours per day while churns are used approximately 12 hours per day. As plant size increases the average number of products produced increases. The small plants produced only one product per plant while the very large plants reported an average of 3.2 products manufactured.

3. Location and Interregional Competition

Changes occurring in the technology of producing and processing agricultural products may have an impact on the comparative advantage of one producing area or processing industry over another. Changes in transportation rates, costs, and services may affect the competitive position of some areas and industries more than it does others. As a result, new firms may be called for in one area while those in other areas may seek alternative opportunities.

Cattle

For-hire motor carriers operating under the agricultural exemption provisions furnish transportation services for much of agriculture's need. A few commodities--eggs, poultry, and livestock, for example--are moved almost entirely by such firms. Reasonable rates and adequate services for these commodity industries thus rely upon intramodal competition. Studies of the exempt trucking sector have examined the nature of the equipment used; the degree of stability in this sector; size of fleets operated; and other factors. It was estimated that exempt motor-carrier firms operated slightly more than 30,000 trucks in interstate hauls in 1963. This was only 4.4 percent of all for-hire trucks in the United States. However, these exempt trucks were operated more miles per year but also with fewer loaded backhauls than were the regulated trucks. Direct measures of the state of intramodal competition in the exempt sector have not as yet been made except for isolated areas.

Transportation rate functions were fitted to data from shipments of cattle hauled by truck and rail both within and between the western States. All functions were linear; that is, nearly all of the variation found in rates for a given type of transportation was explained by the distance hauled. Significant differences in truck rates were found in most between-State comparisons. There was no particular geographic pattern to the between-State relationships. Differences or similarities in rates between States can be explained by differences in truck operating costs, and degree of effectiveness of competition in the transportation of cattle.

It was found that intrastate truck rates for hauling cattle were significantly lower than interstate truck or rail rates for distance up to about 135 miles. Between 135 miles and 290 miles, interstate truck rates were lowest. For distance over 290 miles, rates for hauling feeder cattle by rail were lowest, and for all distance over 390 miles rail rates for slaughter cattle were lower than interstate truck rates. Less than 15 percent of the cattle in the west are shipped by rail and the percentage is continuing to decline. The choice between truck and rail by shippers of cattle is influenced not only by the transportation rate, but also by the speed and convenience of service. Trucks not only offer portal-to-portal service, but averaged 60 to 140 percent greater speed in-transit than regularly scheduled freight trains.

Location and interregional competition research includes other aspects than transportation. A number of research studies were conducted on animal products, grains, and other important commodity areas. A brief summary of some of the findings pertaining to selected commodities follows:

Eggs

As the historical "egg basket" of the Nation, the Midwest has experienced intensified competition in the last decade from growing egg industries in the south and west. For the Midwest to maintain its present position, extensive changes in the size and location of units, in the input-supplying industries, and in marketing practices and channels are needed. More attention must be paid to egg quality, production density, flock sizes, and increased coordination of producing, input-supplying, and marketing functions. If relative returns to producers can be raised, Midwestern farmers might find egg production a better alternative than at present, and others might be more willing to support the investments needed to update the industry in that region.

In 1964-65, dealers buying prices for fluid milk increased an average of 18.2 cents per 100 pounds with each 100-mile increase in distance from Eau Claire, Wisconsin. Areas of lowest and highest prices tended to shrink in size as compared with 1960-61. In addition to distance from major milk supply areas, price differences were also due to (1) Federal, state, and local regulations, (2) supply and demand situations in local markets, and (3) bargaining positions of producers and distributors.

B. Development of Markets

1. Products and Services

Considerable emphasis in the past year was given to markets in which farm products are meeting serious competition. An example is the market for hides and skins. The market for these important byproducts of the livestock industry is seriously threatened by synthetic substitutes, and their impact on the long-range demand for leather and leather products is being studied. Preliminary estimates indicate leather's share of the shoe-upper market, amounting to more than 80 percent in 1965, will decline to about 65 percent by 1975.

Leather products are made even more vulnerable to substitution by inefficiencies in certain marketing methods and practices. In 1965, the value of hides and skins was \$400 million at the meatpacking level, \$900 million after tanning, and \$3.2 billion after manufacturing. Part of this wide margin between the value of raw hides and finished leather products may be due to inefficient marketing methods. An improved method of marketing has been developed wherein unhairing and pickling of the hides is done at the packing-house. A study of the economics of this method indicates that marketing costs can be reduced by \$1.20 per hide.

Findings of research to determine acceptance of modified beverage milk in the Southeast were published. Results indicated that two groups of South Carolina beverage milk consumers preferred different types of beverage milks. Adults always indicated a preference for a sample product containing at least a one percent higher level of total solids than any alternate product sampled. The youth group expressed a preference for a product having less fat and a higher solids-not-fat content than the beverage milk now available in South Carolina.

2. Merchandising and Promotion

Further analysis of milk consumption data resulting from a study on varying levels of promotional investments reveals that some gains resulted from new users. Additional sales data covering a period of 1 year after the sales test ended - March 1965 through February 1966 - indicate the intensified promotion has exerted a residual or carryover sales influence greater than expected of approximately 4 percent after promotional investments returned to normal levels.

A study is being conducted to appraise the economic implication of promotional programs for livestock and livestock products. The impact of promotional programs on prices at various levels of distribution for hogs and the resulting influences on production are being examined. Preliminary analysis reveals significant shifts in the demand for hogs between season, and even months within seasons. Other influences include price of broilers and potential supplies. Similar work is being carried out for lamb and mutton, but with major emphasis on factors influencing distribution and sales.

The range of response to pricing, advertising, and space allocation policies at retail indicates that movement of food products into consumption would be aided by advanced management tools that would give timely evaluations of the effectiveness of these practices. For example, the impact of featuring of specific meat items on margins, costs, returns, total sales and sales of competing meats has been measured through analysis of data collected over a 36-week period in a sample of supermarkets. Findings indicate that relationships resulting from specific product mixes and merchandising practices can be quantified. In turn, these relationships can be used by management in planning features, product mix, or other aspects of meat merchandising with a better understanding of the impact of cost, sales, volume, and profit. Other research in this area is being conducted to appraise the influences of retailer featuring for fresh peaches and apricots on F. O. B. prices received by growers.

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COOPERATIVE MARKETING
Farmer Cooperative Service

Problem: Farmers continue to increase their use of cooperative marketing.

These cooperative operations are conducted in a marketplace where handling and processing, transportation, and distribution technology is changing rapidly, and market organization and practices are undergoing major changes. Farms themselves have changed. Farmers and their cooperatives need research results that relate to these developments and new conditions to assist them in marketing efficiently. Such research will assist farmers to strengthen their bargaining power, increase marketing efficiency, and meet effectively the quality, quantity, and service needs of today's food and fiber marketplace.

Cooperative marketing is a direct and major way for farmers to get maximum returns for their products. Farmers own and operate cooperatives specifically to increase their income from crops and livestock. Gains are not automatic, however. Cooperatives must plan and actually conduct the specific marketing program and services that will yield best returns for their members. Marketing cooperatives must know what the consumer demands, as reflected in the market. They must be able to estimate the cost of serving the market in different ways. They must understand the possibility of major economies in a well-managed joint sales program, and the methods and potentials of bargaining, and the implications of a changing market structure on operations. Management must achieve minimum costs through appropriate organization, good use of existing plant and personnel, and the correct selection and use of new equipment and methods.

USDA AND COOPERATIVE PROGRAM

The Department conducts a continuing long-range program of basic and applied research and technical assistance on problems of marketing farm products cooperatively. Studies are made on the organization, operation, and role of farmer cooperatives in marketing. While most of the research is done to help members directly improve the operation of their cooperatives, the results also often benefit other marketing firms. The work is centered in Washington, D. C. Many of the studies, however, are done in cooperation with various State experiment stations, extension services, and departments of agriculture.

Federal scientific man-years devoted to research in this area involves 3.8 for dairy; 2.9 for livestock and wool; and 2.0 for poultry and eggs.

Research also is conducted under contract with land-grant colleges, universities, cooperatives, and private research organizations. This report includes work conducted during the present period, or release of results of work earlier completed, through contract research performed by colleges and universities in Iowa, North Carolina, and West Virginia, and by one private contractor.

PROGRAM OF STATE EXPERIMENT STATIONS

Most commodity marketing research of the agricultural experiment stations is helpful to marketing cooperatives. Some projects, however, deal specifically with cooperative marketing problems, opportunities, and impacts. The total research effort on cooperative marketing in the State experiment stations is 0.8 scientific man years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Improving cooperative sales, distribution, and pricing methods

Wholesale and retail marketing practices are continuing to change rapidly, and there have been fundamental changes on the farm. For these reasons sales and distribution and pricing methods need to be studied carefully to plan and realize methods and policies that are technically efficient and obtain good returns for producers. Bargaining methods and pooling are two topics that require major research emphasis. Research on these problems included work in several commodities.

1. Dairy. Analysis of sales methods and distribution practice of dairy cooperatives indicate they market most dairy products to wholesale accounts. In 1964 sales federations marketed more than 40 percent of the butter and over 50 percent of the dry milk products manufactured by cooperatives. The study indicates very limited coordination in the marketing of the more perishable manufactured or processed dairy products.

In many of the large fluid milk markets, cooperatives have strengthened their bargaining position through federated marketing programs.

A study of pooling principles and practices is underway. This study has examined the methodology and effects of five closed base pooling plans used by southern and western dairy cooperatives.

Preliminary findings indicate that dairy producers, through their cooperatives, have successfully used these pooling systems primarily to tailor milk production to the seasonal needs of the individual markets. Further analysis will examine the effects of these plans on producers entering and leaving the market and will describe in detail the method of operation of each pooling system.

2. Poultry. A study was initiated to ascertain the marketing functions performed by broiler auctions with emphasis on price influence. Preliminary findings are: (1) Of the 12 broiler auctions organized in eastern United States and Texas between 1952 and 1965, only 3 remain. (2) Most of the broiler auctions selling live broilers made substantial contributions to pricing and prices; however, the impact of higher prices served to restrict output and the most rapid growth occurred in areas with lowest prices and limited alternative employment opportunities. (3) Four states in which broiler auctions were discontinued have the lowest live broiler prices in the United States. And they have the fastest income growth from broilers. (4) Live broilers in 1952 were sold from many independent producers to processors. A few integrators patronized each of the auctions operating in 1965 to balance their supplies with sales contracts and orders. (5) Since many sale commitments are made before the auction starts, it is possible for integrators to match long and short supplies with sales commitments while they participate in the pricing process. (6) It is possible for less than 5 integrated feed dealers and processors to maintain a successful auction. (7) Production area quotations provide a basis for negotiating production contracts. (8) Auction prices can serve as a starting point in negotiations for ready-to-cook sales in metropolitan areas; however, a smaller volume is traded each year.

A study of pooling and producer payment practices of egg marketing cooperatives shows that most associations use a market price quotation and a system of differentials in paying egg producers. Pricing differentials vary widely among the 18 cooperatives studied. Variation in value relates to costs, savings, and nature of competition. Individual producer payments based on the cooperative's cost of serving him are more equitable than individual payments based on the cooperative's average costs. Likewise, each patron's net savings based on his contribution to savings is more equitable than determining partons' net savings on an average basis.

Only a few farmer cooperatives calculate producers' net savings and losses in proportion to differences in volume, quality, distance, and marginal cost of serving each producer. Large volume producers find price differentials related to an individual member's cost more attractive than payments based on average cost of the entire association. Equitable treatment of the largest egg producers is necessary in keeping them in a cooperative with small volume producers. Savings resulting from efficiency of size are necessary for egg producer cooperatives to remain in business and maintain access to markets.

B. Potentials in cooperative marketing

The present and potential role of cooperative marketing requires study in several commodity areas. Current information on cooperative operations can be related to production and marketing conditions.

The objective of such research is to develop recommendations about operations and services of existing cooperatives and particularly to identify opportunities for farmers to increase their marketing returns by developing significant new areas of cooperative operation.

1. Dairy. A study of cooperative marketing activities shows that only 1,245 dairy cooperatives operated for their full 1964 fiscal year. Yet, volume of milk marketed had increased to 76 billion pounds -- two-thirds of all milk sold to plants and dealers. The cooperative structure, nevertheless, continues to be largely that of a local organization operating a single plant facility. Out of 1,025 cooperatives operating milk handling facilities, only 89 had more than one plant facility and only 16 of these had 5 or more plants.

Further analysis is being made of cooperative plant locations, major equipment and operating capacity in exploring potential benefits to dairy farmers from increased coordination of their marketing activities.

2. Fowl. A study was initiated to determine the feasibility of establishing cooperative marketing facilities in the northeast to market fowl.

3. Livestock. Studies were made to determine the extent of horizontal and vertical integration among livestock marketing and related cooperatives. Livestock producers, through their cooperatives, have moved to integrate their cooperative activities, but to date they have made only modest progress towards fully integrated operations.

A guide was developed to assist livestock marketing cooperatives that wish to enter the various phases of livestock production, feeding, marketing, slaughtering, processing and distribution of livestock and meat products.

Preliminary findings of a study in the New England States relating to the feasibility of cooperative slaughtering, processing, and marketing of the end products of cull dairy cows and veal calves indicates that there are opportunities to increase the returns to farmers in that region.

4. Turkeys. Research was initiated to appraise the scope and potential of turkey marketing cooperatives in the United States.

C. Improving operating and handling methods

Research was underway in several commodity fields to examine new methods, equipment, and structures of efficient and safe processing and storage of agricultural products by cooperatives.

1. Dairy. A study is underway to develop a standard departmentalized cost accounting system for management of dairy cooperatives that will provide management with information needed to better control costs and improve efficiency and quality of service.

Work on the operating practices and procedures of a fluid milk packaging cooperative is underway. Preliminary findings indicate that changes in procedures and material handling systems will reduce costs \$40,000 a year.

2. Livestock. Work continued on a study of pooling of veal calves at group of cooperative auctions. The study included the feasibility of such an undertaking and the procedures which must be adopted and followed to assure efficient and successful operations. The findings of this study will be useful not only to the auctions studied, but to other auctions interested in adopting pooling.

Findings in studies of four cooperatives in Wisconsin indicate it would be advantageous to livestock producers for these cooperatives to merge into one State-wide association. Farmers would gain greater bargaining power, marketing costs would be lowered, and services would be improved.

A study of two large livestock cooperatives serving Iowa, Nebraska, Kansas, Missouri, and portions of adjoining states shows that cooperatives serving livestock producers in that area need to make organizational and operating adjustments to provide the services needed by large-scale livestock producers and to be effective in a changed marketing environment.

D. Improving the organization, financing, and management of marketing cooperatives

Studies were made to determine ways to improve the efficiency and assist cooperatives improve their services by analysis of organization, financing, and management practices.

1. Dairy. A study was made to determine the feasibility of unifying the fluid milk bottling and manufacturing operations of a group of cooperatives serving farmers over a relatively broad area. The study indicated that, with consolidated operations, returns to farmers would be increased by \$650,000 annually.

Two case studies to determine the feasibility of unifying operations of Grade A bargaining association with cooperatives primarily engaged in manufacturing dairy products are underway.

2. Poultry. A study was completed of the feasibility of coordinating or merging several producer organizations in four New England States. Findings indicate that it was not feasible to consolidate feed operations, but egg marketing activities should be consolidated and merged. A study was made of the poultry industry in southern California to determine the long range potential for feed cooperatives in the area and adjustments such cooperatives must make to better serve producers as they increase the size of their flocks.

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ECONOMIC AND STATISTICAL ANALYSIS
Economic and Statistical Analysis Division, ERS

Problem: Frequent accurate appraisals of the economic prospects for important agricultural commodities are necessary if farmers are to plan and carry out their production and marketing activities in an efficient and profitable way. The typical farmer cannot afford to collect and analyze all the statistical and economic information necessary for making sound production and marketing decisions. Such information is provided through a flow of current outlook information, the development of longer range projections of the economic prospects for the principal agricultural commodities, and analyses of the economic implications of existing and proposed programs affecting major farm commodities.

Producers, processors, distributors, and consumers need information based on accurate quantitative knowledge of the interrelationships among prices, production and consumption of farm products, and other factors. Similarly, Congress and the administrators of farm programs need such economic information to evaluate existing and alternative programs or policies in terms of their probable impact on production, consumption, and prices at both the farm and retail levels. The research program in this area provides the information for strengthening outlook and situation work, and for appraising alternative policies for agricultural products.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-range program of economic and statistical analysis directed in two major areas: (1) commodity situation and outlook analysis, and (2) supply, demand, and price of agricultural commodities.

The program pertaining to situation and outlook includes a continuous appraisal of the current and prospective economic situation of the major crop and livestock items. These appraisals, together with developments of interest to the industry and results of special studies, are published four to six times a year in the various commodity Situation reports. Brief resumes are carried in the quarterly Demand and Price Situation and when appropriate in monthly issues of the Farm Index and the Agricultural Outlook Digest. Pertinent information is also presented at the Annual Outlook Conference, at regional and State conferences, and at meetings with industry groups. Statistical handbooks are published periodically for livestock and a number of the field crops.

Except for a regional field office for livestock in Denver, Colorado, which is a cooperative effort with the Federal Extension Service and State Extension Services in the western states, all the USDA commodity situation and outlook work is carried on in Washington. The Federal effort involves 4.5 scientific man-years for livestock and meat of which 2.0 are in Denver, 2.0 for dairy, 1.0 for poultry and eggs, and 1.5 for wool.

The program of basic research into the factors affecting prices, supply, and consumption of principal agricultural commodities is concerned with four broad areas: (1) Measurement of consumer response to price, income, and other factors; (2) measurement of producer response to price and other factors; (3) measurement of the effect of supply and demand factors on prices to farmers and to consumers; and (4) improvement of statistical techniques for measuring economic relationships in agriculture.

A facet that is becoming increasingly important in carrying out the statistical and econometric work of the Division is the use of electronic computers. The program includes continual evaluation of latest developments in the field, equipment and computer programs available, and use of improved equipment and techniques in problem solving.

The USDA program of research in this area is located in Washington, D. C., involving the following scientific man-years: Livestock and meats, 1.0; poultry and eggs, 0.5.

PROGRAM OF STATE EXPERIMENT STATIONS

For the most part the states depend heavily on the USDA for across-the-board commodity situation and outlook research. However, The State Extension staff members supplement and adapt such research information to meet the commodity situation of their states. The total direct research effort at State Experiment Stations in the situation and outlook area is small -- probably no more than 2 to 3 scientific man-years.

Many of the states carry on supply, demand, and price analyses for the products of their state. Much of the research is commodity-oriented, though some projects are of a highly mathematical and theoretical nature aimed at improving price analysis methodology.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Commodity Situation and Outlook

1. Livestock and Meat

Several topics in the livestock area received special attention during the past year. Major consideration was given to the downturn in the cattle cycle and how the current cycle has differed from earlier cycles. A special article in the March issue of the Livestock and Meat Situation centered on structural changes in the industry as well as on outside forces which altered the current downturn from earlier ones. The August situation stressed the inventory decline in cattle and the probable effect this will have on future beef production. An analysis of the relationship between prices of feeder pigs and feed costs and expected hog prices was published in the March issue. The

analysis showed that the breakeven price in buying feeder pigs varies considerably depending on the cost of feed and the market price for slaughter hogs at the end of the feeding period.

2. Dairy

During the past year attention has been given to the shifting supply-demand balance for milk and dairy products, which has resulted in the disappearance of government stocks and in stronger market prices; and to the evaluation of alternative programs for assuring adequate supplies of dairy products. The world dairy situation and U.S. imports of dairy products were followed closely because of changing U.S. import-export conditions following the 1965 and 1966 declines in milk production.

In response to industry interest for improved consumption data that recognized the increased use of low-fat products, new series were developed to provide information on total and per capita sales of dairy products by product weight and in terms of milk solids, as well as milk equivalents. Because of declining farm use and changing levels of CCC donations, sales and consumption data show considerably different trends. Per capita sales have been fairly stable in the last 5 years while per capita consumption has declined. Problems of dairy labor scarcity and increasing wage rates led to an analysis of trends and prospects for dairy labor. Special studies were made of the butter situation, prices and margins for dairy products, and veal production.

3. Poultry and Eggs

Much effort was devoted to analyzing the impact of the vigorous growth in demand for high-protein foods on poultry and egg production and prices. This upsurge in demand was generated by the rapidly expanding economy. As early as November 1965, a large expansion in broiler and turkey production but little change in egg production was forecast for calendar year 1966. Early in 1966, analyses indicated that production expansion in poultry would accelerate during the year and that a large buildup in laying flocks was getting underway. Demand was increasing rapidly and prospects were for another sizeable gain in farm income from poultry and eggs in 1966. However, by September it was becoming evident that broiler and egg production might accelerate further in 1967 and that feed prices in early 1967 probably would be above a year earlier. Producers were warned that if current trends continued, output would be so large during the first half of 1967 that returns might be sharply reduced.

Several other topics also received attention. The November 1965 issue of the Poultry and Egg Situation presented preliminary findings of a study of factors influencing turkey prices during and before the heavy marketing period. The April issue featured a comprehensive article on futures trading in fresh eggs. Trading in these contracts had been initiated by the Chicago Mercantile Exchange in February. A statistical bulletin was published in May as a supplement to the Poultry and Egg Situation.

4. Wool and Mohair

U.S. military purchases of wool fabrics were reviewed in 1966. The probable effect of the military situation in Vietnam on future domestic wool prices was analyzed. Special materials were prepared for the National Commission on Food and Fiber. Attention also was given to the probable impact of possible tariff reductions in the GATT negotiations at Geneva on domestic wool prices and program operations under the National Wool Act. Seasonal adjustment factors for wool consumption were revised.

B. Supply, Demand and Price

1. Livestock and Meat

An analysis of the seasonal variation in hog slaughter, hog and pork prices, and pork consumption was completed and results published in the August 1966 issue of the Livestock and Meat Situation. Emphasis was placed on changes in seasonal patterns over time and on the relative contribution of the seasonal nature of production to total variation in hog slaughter, prices and consumption. Barrows and gilts in July reached a seasonal low in slaughter 24 percent below the 12-month average and a seasonal high in prices about 12 percent above the 12-month average. Slaughter then increased to a high 15 percent above average in October, and prices declined to a low 4 to 5 percent below average in November. Seasonality accounted for about 70 percent of the month-to-month changes in hog slaughter, but only 40 to 45 percent in the variation in hog prices. A similar analysis is underway for cattle slaughter and cattle and beef prices.

A paper was prepared and presented at the summer meeting of the American Farm Economics Association on the "Performance of the Livestock-Feed Grain Sector." There has been a trend in the past two decades toward greater stability in feed grain production and prices and in livestock production. However, the same definite trend cannot be detected with respect to prices received by farmers for livestock, particularly hogs. Forecasts of placements and marketings of fed cattle are based partly on relationships of the past. A limiting factor in making analyses designed to measure these relationships has been the lack of a uniform series for past years. A series for marketings and placements was developed and published in the October 1965 Situation.

Progress was made on improving the quarterly supply model developed in 1962 for determining the number of sows farrowing and the slaughter and price of hogs. Additional factors are being considered to adapt the model to recent structural changes in the industry. Also, further work was done to refine models used in forecasting domestic production of beef, veal, mutton, and goat meat for the coming calendar year. These forecasts are required to determine whether the President proclaims import quotas under the 1964 meat import quota legislation (Public Law 88-482).

2. Poultry and Eggs

A statistical analysis was made of factors influencing turkey prices during the heavy and light marketing period. Results, which include price-estimating equations, were published in the April 1966 issue of Agricultural Economics Research. Demand for turkeys at the farm level was found to be inelastic during the main fall marketing period, September-December, but elastic in January-August. Consequently, prices in the fall were considerably more responsive to changes in supplies than prices earlier in the year. Fall turkey prices were found to be measurably influenced by only two factors--per capita turkey supplies and the change from a year earlier in per capita poultry consumption in January-August. Other things being equal, an increase of 5 percent in per capita turkey supplies from commercial sources (excluding USDA purchases) during September-December was followed, on the average, by a 10-percent decrease in the turkey price. Year-to-year changes in per capita poultry supplies (including chicken) prior to the main marketing season were significant in affecting the September-December price, while the absolute level of per capita chicken supplies during this heavy marketing period was not. This strongly suggests that heavy consumption of poultry early in the year tends to weaken demand for turkey later in the year. In the January-August period, per capita supply of chicken did measurably affect turkey prices.

This Division is participating in an ERS study on interregional competition in eggs. Emphasis is on problems faced by the Midwestern egg industry in attempting to maintain its historical role as the "egg basket of the Nation." Attention will center on structure and practices of the industry in various regions and the probable regional shifts in egg production, given prospective changes in the producing, input-supplying, and marketing segments of the egg industry. The first phase of this study is expected to be released late in 1966.

3. Program Analysis

A survey was made of one-half the readership of the Livestock and Meat Situation to determine how the report was used and how it could be improved. Of 3,500 schedules sent out, 2,366 were received and edited; the data were punched on cards and tabulated by various categories. Plans are being formulated for similar surveys of other situation reports published by the Division.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

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Seaborg, Donald. April 1966. Feeder's Margins. Agricultural Situation, USDA, p. 3.

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Livestock and Meat Statistics. August 1966. Supplement for 1965 to Statistical Bulletin No. 333, ERS, USDA, 162 pp.

Dairy

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- Miller, Robert H. May 1966. Milk Prices and USDA Programs. Dairy Situation, USDA, p. 25-29.
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- Schlechty, David L. September 1966. World Dairy Situation. Dairy Situation, pp. 24-25.

Poultry and Eggs

- Bluestone, H. Poultry and Egg Situation. Published 5 times a year. ERS, USDA. Washington, D. C.
- Bluestone, H. November 1965. Predicting Prices for Turkeys, Poultry and Egg Situation, pp. 21-24.
- Bluestone, H. April 1966. Futures Trading in Fresh Eggs, Poultry and Egg Situation, pp. 15-22.
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Wool

- Clayton, Larry B. Wool Situation. Published quarterly. ERS, USDA. Washington, D. C.
- Supplement for 1965 to Wool Statistics and Related Data, 1920-64, August 1966. USDA Statistical Bulletin No. 363.

B. Supply, Demand and Price

Livestock and Meat

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Seaborg, Donald. March 1966. Cattle Feeding and Feeding Margins. Livestock and Meat Situation, pp. 28-32.

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Poultry and Eggs

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Supply, Demand and Price

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CONSUMER PREFERENCE AND QUALITY DISCRIMINATION --
HOUSEHOLD AND INDUSTRIAL
Standards and Research Division, SRS

Problem. Domestic consumption of agricultural commodities depends on the behavior of some 190 million consumers. But, in our complex marketing economy, it has become almost impossible for consumers to discuss their preferences, opinions, and dissatisfactions with producers and marketers. Knowledge of consumer reactions to agricultural products is becoming increasingly important because we are in a period of rapid change: There is a growing challenge to farm products and farm income from a wide variety of competitive products of nonagricultural origin; there is a proliferation of mixtures, forms, processes and other innovations affecting farm products; and there is increasing awareness that mistakes in developing, producing, and marketing farm products are costly not only to the farmer but to processors and handlers as well. An understanding of consumer reactions and the reasons behind them is essential to planning improvements in the production, marketing, and processing of agricultural products, developing educational programs, setting or revising grades or standards, evaluating new products developed by the Department's Utilization Laboratories, and identifying areas on which technical research should be focused to provide farm products in the forms and with the characteristics that will increase consumer acceptance and more closely satisfy consumer demand.

USDA PROGRAM

The Special Surveys Branch provides the consumer, in a scientific and unbiased manner, with an opportunity to say what he or she thinks about agricultural products by conducting applied research among representative samples of household, industrial, or institutional consumers and potential consumers. Such research may determine preferences, opinions, buying practices, and use habits with respect to various agricultural commodities; the role of competitive products; acceptance of new or improved agricultural products, consumers' ability to discriminate among products with varying attributes, and the preferences associated with specific forms. These studies of the opinions, preferences, knowledge and habits of consumers which affect their purchase and use of farm products provide a line of communication from consumers back to those concerned with production, and marketing, and are complementary to the marketing and economic research of the Economic Research Service and the Consumer and Marketing Service as well as to utilization research of the Agricultural Research Service.

In addition to conducting studies of consumer preference and discrimination, the Branch also provides consultants and conducts special studies, upon request, for other agencies in the USDA or within the Federal Government, when survey methods can be usefully applied to the evaluation of programs, services, or regulatory procedures of interest to the requesting agencies.

The research is carried out in cooperation with other USDA or federal agencies, state departments of agriculture, experiment stations, land-grant colleges, and agricultural producer, processor, and distributor groups. Closely supervised contracts with private research firms are used for nationwide surveys; studies in selected areas are sometimes conducted by the Washington staff with the assistance of locally recruited personnel.

The Branch maintains all of its research scientists, who are trained in social psychology or other social sciences, in Washington, D. C., which is headquarters for all the research whether it is conducted under contract or directly by the Branch. The Federal scientific effort devoted to research in this area during the past year totaled 7 scientific man-years including 0.5 for dairy; 0.4, poultry; 0.4, livestock; and 0.3, wool.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Consumer Preference

1. Fibers in wearing apparel. A nationwide survey is being conducted under contract by a private market research firm to ascertain women's opinions about fibers in apparel for warmer weather. Two types of questionnaires--one structured and the other with many questions unstructured--were employed in the final interviewing, which took place in the Fall of 1965. Coding and tabulation of the data have been completed, and a final report presenting the findings is in preparation.

A contract study on reactions to fibers in selected items of clothing among a nationwide sample of teenage boys and girls has been completed, and the final publication which presents detailed findings has been released. Some highlights of the findings follow.

The teenage boys and girls interviewed reported that cotton, wool, and cotton-polyester blends--the three most frequently owned and preferred materials in the garments selected for study--have their good points, but a few bad ones too. The major reasons given for preferring cotton were that it is cool, easy to wash and iron, nonirritating, durable, and not too warm. The main disadvantages mentioned were that cotton wrinkles and that it is not warm enough for some purposes. Wool was preferred mainly for its warmth and wrinkle resistance, but also for its soil resistance and durability. The complaints against wool were that it irritates the skin, that it is not washable, and that it is too warm. Cotton-polyester was liked because it is wrinkle resistant and easy to iron. A disadvantage of cotton-polyester mentioned by the girls was that it discolors. The girls were more likely to give launderability features (such as easy to wash, easy to iron) as reasons for their preferences than the boys were. This is presumably because girls are more likely than boys to take charge of caring for their clothes.

The majority of the teenagers reported that they were very interested in both the kinds of clothes they wore and the selection of the clothes. Although a majority of both the girls and boys reported that they were the ones who suggested the need for a new item of clothing, they said that their mothers usually had the most to say about whether or not they might buy it. However, boys were more likely than girls to mention that their fathers had the most to say about whether or not they would get a new item of clothing. The teenagers were more likely to say that they themselves suggested the need for and had the most to say about the purchase of girls' skirts or blouses and boys' shirts or sweaters than about girls' coats and dresses or boys' outer jackets and sport coats, which would generally be more expensive.

The majority of the girls reported that they either shopped alone or shopped with their mothers for their clothing, while the boys most frequently said that they shopped alone or that their mothers shopped alone for their clothing. Although the parents had the most to say about whether the teenager would get an article of clothing, the teenagers indicated that they had the most to say about the article that was finally selected.

2. Materials in shoe uppers. A contract has been signed with a private market research firm to study the attitudes and opinions of consumers concerning leather, primarily in shoe uppers. The survey, which will be conducted among approximately 500 men and 500 women in the Philadelphia, Pa. area, will investigate consumers' opinions about the advantages and disadvantages of leather compared to competitive synthetic products being introduced on the market, and their impressions of the desirability of potential improvements in leather for shoes. If necessary, additional interviews will be conducted among users of "Corfam" shoes in an effort to obtain a large enough number for separate analysis. A few questions will also be included on opinions about leather in other clothing items, and natural fibers in shoe uppers. The interviewing on this study is tentatively planned for early 1967.

3. Milk. A study (financed in part by ARS) is underway to evaluate consumer acceptance of powdered dry whole milk, a new product developed by the Dairy Products Laboratory of the Eastern Utilization Research and Development Division, ARS. Over 300 households in the city of Alexandria, Virginia, tried the new product in their homes. Forty-four percent of the respondents felt that the dry whole milk was equal to or better than fresh considering their family's over-all needs and preferences, while 53 percent thought it was not as good. This rating of dry milk does not appear to be related to amount of fresh milk used per week by the family. The disadvantage of the test product which was cited most often concerned the time the milk took to prepare.

A question of special interest is whether or not the problems of foam or residue on the dry milk and difficulties in mixing it were particularly dominant in the thinking of those who gave negative ratings to the milk. Indications are that these reasons do not seem to be given much, if any, heavier weight than all other disadvantages.

These results are selected and preliminary. A final report of the findings of this study will be published in 1967.

4. Pork and beef. A contract has been signed with a private research firm to gather information from a nationwide sample of homemakers on their use of and opinions about meat items, particularly pork and beef. An exploratory study will precede the main survey so that factors pertinent to the main survey will not be overlooked. Questions tentatively will be oriented toward data that underlie the reasons behind increased consumption of beef on one hand and decreasing consumption of pork on the other. The field work on the main survey is scheduled to start early in 1967, and will cover all quarters of that year. The National Live Stock and Meat Board is cooperating with the Department in this study and is providing a portion of the funds for the research.

5. Poultry. A nationwide survey was conducted in the summer of 1964, under contract by a private research firm, to ascertain household consumers' preferences, use patterns, and purchasing practices for broiler-fryers and turkeys. Some of the questions were designed to elicit information for comparison with an earlier (1956) study. The final report on this study has been published. A few highlights from the report (some of which have been discussed in a previous progress report) are outlined below.

The current data show that 97 percent of the interviewed homemakers reported serving broiler-fryers during the year preceding the survey, an increase of 4 percentage points from the earlier study. Frequency of use also increased; almost two-thirds of the users in 1964, compared to half the users in 1956, reported serving broiler-fryers once a week or more often. Price appeared to be the key factor in stimulating more frequent use of broiler-fryers. Increased use of broiler-fryers for weekday meals, winter consumption, and outdoor cooking also seem to account for increased consumption.

Most homemakers reported being able to purchase broiler-fryers in the weight range that suited their family's needs. Purchasers of broiler-fryers were asked to choose characteristics that they felt were most important in selecting these birds. About 7 in 10 chose "one that is well cleaned", "no bruises or discoloration", and "the right size". About 6 in 10 selected "inspected by the government", 5 in 10 choosing "no pinfeathers" and "plumpness".

When asked which of three poultry grade levels--words, letters or numbers--would be the easiest to understand, almost 60 percent selected words, 30 percent chose letters, and only 5 percent felt that numbers would be easiest to understand.

Commercially frozen chicken has not achieved wide acceptance. Only one-third of the women who purchased broiler-fryers in the year preceding the survey reported buying any that were frozen. Major deterrents appeared to be price, availability, and a lack of knowledge as to how long store chicken had been frozen. Home freezing of chicken, however, was popular among homemakers, especially among those with separate freezers.

Homemakers tended to view chicken as a convenient, versatile, economical, and tasty food item. They did not feel that broiler-fryers were particularly suitable for festive occasions, as a meat for sandwiches, or as an item to order when dining out.

The percentage of homemakers who reported serving turkey (76 percent) increased by 11 percentage points since the 1956 study. Most women, however, still served turkey only one to three times a year. Fresh turkeys were preferred over frozen by a three-to-one ratio, while hens were preferred over toms two-to-one.

About two-thirds of all homemakers had bought one or more convenience poultry products during the year preceding the survey. The most popular items with consumers were frozen chicken pies, frozen turkey pies, frozen chicken dinners, and frozen turkey dinners in that order.

B. Quality Discrimination

The sensory testing laboratory of the Branch is used to ascertain, under controlled conditions, people's abilities to discriminate among qualities or levels of a quality for food samples, or other sensory or visual stimuli, and the preferences associated with discriminable variables. The products which have been evaluated include new food forms developed in the ARS laboratories or variations of products already available. Studies have been conducted this year on dry whole milk; orange drinks vs. orange juice; dehydrated lemonade, limeade, orange juice and grapefruit juice; three varieties of a new spread-type dairy product; three flavor variations of a new type lo-fat cheese; and dehydrated apple, cherry and grape juices. Some examples of the types of problems investigated are listed below. The results of these studies are not usually published, but are reported by memorandum to the cooperating group requesting the research.

Milk. A series of tests is being conducted to test people's reactions to dry whole milk after varying periods of time in storage at three different temperatures; i.e., 40°, 68°, and 80°, Fahrenheit. This milk is the same product discussed above (1-A-3) which was developed by the Eastern Utilization Research and Development Division, ARS. The most recent test, conducted after the milk had been in storage for 6 months, was to have been the last. However, because the mean preference scores for all three milks remained above the neutral point on the hedonic scale throughout the study, and because additional supplies of the storage milks are on hand, the tests will be continued on a monthly basis for an indefinite period.

Lo-fat cheese. A series of tests was run on three flavor variations of a new lo-fat cheese, developed by the Eastern Utilization Research and Development Division, ARS. The new cheeses had a lower butterfat content (6 percent) and a higher protein content than most cheeses. Tests were conducted to determine differences in preferences among the new cheeses themselves, with no significant differences being found. Two flavor variations of the new cheeses were then tested against a commercially available lo-fat product, which was preferred. Finally, two flavor variations of the new cheeses were tested against a commercially available New York sharp cheddar, and no significant differences among the overall preference scores for these cheeses were found.

PUBLICATIONS

Consumer Preference

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Knott, Edward M. 1966. Homemakers' Opinions and Preferences for Broiler-Fryers and Turkeys. Marketing Research Report No. 760. (S&R 3-8)

